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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

MARCH 14.
Institute of Metals (Scottish Local Section):—Annual general meeting at Glasgow. "Some Notes on Condenser Tubes and their Packing," Paper by J. Stirling.

MARCH 15.
Sheffield Metallurgical Association:—Ordinary meeting. "Modern Magnet Steel Castings," Paper by John Swan, M.Met.
Institute of Metals (North-East Coast Local Section):—Annual general meeting at Newcastle-upon-Tyne. "Refining of Copper," Paper by R. D. Biron, M.Sc.

MARCH 16.
Manchester Metallurgical Society:—Annual general meeting and Presidential Address.

MARCH 17.
Co-ordinating Committee:—Joint meeting at Birmingham. "The Extrusion of Metals," Paper by R. Genders, M.B.E.
Institute of Metals (London Section):—Ordinary meeting. "The Efficacy of Testing Methods," Paper by H. J. Gough, M.B.E., D.Sc.
Institution of Welding Engineers:—Ordinary meeting in London. "The Arc-Welding of Structural Steel," Paper by J. H. Paterson, D.Sc., F.I.C.

Institute of British Foundrymen.

MARCH 18.
Sheffield and District Branch:—Ordinary meeting. "Notes on Steel Foundry Practice," Paper by C. D. Pollard.

Testing of Castings.

We give elsewhere in this issue the opening contribution by Dr. Rosenhain to a discussion held this week by the Institute of Metals on the testing of castings. It is a decided innovation for a body dealing with non-ferrous practice to include in its scope a discussion covering the ferrous as well as the non-ferrous metals. There is, however, something to be said for this, in so far as all the cast metals exhibit certain properties in common, and their testing offers the same problems to the engineer and founder. We are, therefore, glad that our recent suggestion that iron founders should be represented in this discussion has borne fruit. Dr. Rosenhain's Paper will be read with great interest by all iron founders. It states the case for the fundamental principles governing the testing of castings with admirable clearness and precision. The conclusions reached will interest and gratify all foundry metallurgists, because they offer wholehearted support to the basic idea of transverse and tensile tests on a separately-cast bar, the section of which bears some proportion to the section of the casting which it represents. With the weight of Dr. Rosenhain's authority and impartiality it will be of great encouragement to those who have been responsible for promoting this point of view. We do not need to remind our readers that it was first promulgated by iron founders, and after about seven years' effort became embodied in a national specification. Although a determined effort was made by some Continental countries to establish the small test-piece taken from the casting as an international acceptance test, the British principle was overwhelmingly supported. In this connection we recommend our readers to study carefully the appendix of Dr. Rosenhain's Paper. This does not necessarily represent his personal point of view, which is given in the body of his contribution. It represents a considered attempt to estimate the trend of European feeling on this question after half-a-day's discussion opened by Papers from well-known authorities:—Prof. Piwowarsky of Germany, Prof. Portevin of France, Prof. Pisek of Czecho-Slovakia, Dr. Dubi of Switzerland and Mr. J. G. Pearce for Great Britain. As President of the section of the Zürich Conference dealing with the metals, Dr. Rosenhain was asked to prepare a judicial summary; he had the advantage of examining preliminary memoranda of an impartial rather than a partisan character from Dr. Benedicks, Dr. Dubi, Mr. Pearce and Prof. Portevin. We cannot do better than close with the following two quotations, which summarise the situation and which so clearly foreshadow the trend of the international specification for testing cast iron. The first is taken from Dr. Rosenhain's Paper, and the second from his Appendix.

"A full discussion of the subject at the Congress at Zürich . . . clearly showed, however, that the consensus of opinion among the testing engineers and metallurgists of the world was strongly against the use of these small test-pieces cut from the castings themselves, and definitely in favour of the use of specially cast test-bars."

"The position may be summed up briefly by saying that, in the opinions of the great majority of those who took part in the discussion at Zürich, the use of a separately-cast test-bar to be tested in tension and bending, is to be regarded as satisfactory and sufficient for the majority of industrial purposes, but that for the exploration of the properties of various parts of castings, and for the study of variations from one casting to another of the same type, and also for the investigation of castings which have failed in service, the small test-piece, cut from the casting itself, should be adopted."

For the Attention of the Buyer.

It appears to us that the engineers' buyers could render a signal service to the foundry industry by being much more explicit in stating their requirements. One buyer we have encountered invariably multiplies his actual requirements by five, thus hoping to have all the benefits of being a big buyer without actually being one. Delivery date can also influence price, and we suggest that the buyer should state what delay he can accord, rather than ask the supplier to state his period.

A "snag" often encountered is embodied in the phrase, "We will supply patterns." The recipient wonders whether this means a battered wooden contraption or a dozen metal patterns nicely affixed to a plate ready for attaching to that moulding machine which has been waiting for a month for such a job. The influence on the price quoted is, obviously, enormous.

The next question is, Where are the important surfaces on the castings scheduled on an inquiry? This, again, is a piece of information invaluable to the founder endeavouring to make an intelligent quotation. Again, the question of weight is just as important when a buyer is asking for a price per casting as when he asks for an overall price per ton, because if he states that a casting weighs so many pounds, and this proves to be incorrect, he should certainly pay for his own mistake where serious quantities are involved. If a buyer is in a position to state his annual requirements and the frequency of his orders, he will often assure for himself a better price, as it may enable the founder to install

(*Concluded on page* 166.)

The Testing of Castings.*

By Walter Rosenhain, D.Sc., F.Inst.P., F.Inst.Met., F.R.S.

The testing of castings presents many difficult problems which are of importance both to the founder and to the engineer. At the present time the whole question is of particular interest because it has been the subject of much discussion both in connection with the proposed revision of certain British Standard Specifications and also in relation to the testing of cast iron. The latter question formed the subject of a particularly active discussion at the Zürich Congress of the International Association for Testing Materials. No apology is required for including the subject of cast iron in the present discussion on the testing of castings, since the problems are, in many respects, identical. A general discussion of the subject at a meeting of the Institute of Metals should prove helpful to all concerned with these questions, since the manufacturer of castings, the user of castings, the scientific investigator, and those engaged professionally in testing are all interested, and there is probably no gathering where all these groups can meet on more even or more friendly terms than at the present meeting.

Object Sought.

Before considering the various possible methods of testing, it is desirable to define the purposes for which tests are to be carried out. Of these purposes probably the widest and most important is that of ascertaining whether a given delivery of castings meets the requirements of a specification. This may be called reception or specification testing. In addition, there is a type of testing, also for immediately practical ends, which is applied for the purpose of enabling the makers of castings to maintain the requisite quality. This type of testing, where it is employed, may be described as control testing. Finally, there is a third type of test which is made for the purpose of investigation, most frequently in order to ascertain the qualities of new materials or the effects of new processes or methods of production or treatment. In addition, there is also the occasional necessity to investigate the causes of failures which may occur either during manufacture or in service. This type of testing may be described as investigatory.

In the present discussion attention may well be concentrated upon the first two types of testing, since for investigatory purposes many special methods may become applicable which are not of such general interest and importance as those which have to be employed day by day in manufacture and reception.

Control Testing.

The requirements of reception and control testing are very similar, and the possibilities of the methods which can reasonably be employed are limited by the need for simplicity, cheapness and speed. The tests specified and the methods used for carrying them out must not add unduly either to the cost of the material or to the time required for delivery. On the other hand, the tests should be, if possible, such that they give an adequate insight into the quality of the castings and assure to the user the necessary degree of strength, ductility and other properties which he may require. It is the difficulty of reconciling these two types of requirements which gives rise to the divergence of opinion and widely differing methods which one has to consider in the present discussion.

X-Ray Testing.

An ideal test should be capable of being quickly applied to every casting without injuring it in any way. At the same time, it should give full data in regard to the strength and quality of the material. Obviously, no such method of testing is yet available, but it must not be supposed that the development of some such test is entirely outside the bounds of possibility. In the case of magnetic materials such as heat-treated steel forgings or stampings, it has now become possible to apply rapidly and certainly to every piece produced a test which will readily reject those with properties which fall outside certain narrow limits. Some attempts have been made to develop magnetic methods of testing non-ferrous alloys, but although some promising results have been obtained, the development has not yet been carried far enough for practical application. It would not be surprising, however, if in the future some means of investigating the quality of a piece of metal, even of non-magnetic non-ferrous metal, could be found which would make it possible to examine every individual casting in a very short time. In this connection brief mention may be made of the use of X-rays in examining castings. Two methods of utilising X-rays are available. One consists in passing a sufficiently powerful beam through the casting with a view to discovering cavities or unsoundness. This is much too slow and expensive a process to be used in routine practice, and its application must therefore be confined either to the examination of very important castings or particularly important places in special cases, or to the study of methods of casting directed to the end of eliminating the occurrence of serious internal defects. X-rays have been successfully used for both purposes, but cannot be regarded as suitable for routine commercial use at the present time. The second method of using X-rays which has found such wide application in the scientific study of the crystal structure of metals and alloys makes it possible to form estimates of the size and predominating direction of crystals in a given piece of metal. Again, the application is not of a nature which could be used for routine purposes, and must still be regarded as limited to investigatory work.

Specific Gravity as Measure of Soundness.

Another method which may be mentioned in this connection consists in determining the density of an entire casting, as, for instance, by weighing first in air and then in water or other liquid. By this method the occurrence of unsoundness can readily be detected, and it might be possible to develop means for making tests of this kind which would render them applicable in practice to castings of moderate weight. In cases where the absence of unsoundness is of sufficient importance, this method of testing, which, it should be noted, is non-destructive, might well be applied. It is in use to a limited extent in certain industries at the present time.

Mechanical Testing.

Turning now to the more familiar types of testing which are concerned with what may be described as the mechanical properties of a casting or of the material of which it is made, there are broadly two questions that have to be answered. The first is what type of sample are we to use, and the second what type of test is to be applied. Since the type of test necessarily depends on the type of sample, we may perhaps consider the question of the sample in the first place.

Since the engineer naturally desires to know the properties of the casting which he actually uses, it would at first sight appear rational that we should test one or more actual castings out of those which are to be supplied. There are, however, difficulties in the way of carrying out this apparently simple and rational method. Where the castings are small and supplied in considerable numbers, the sacrifice of a certain percentage of individual castings for testing purposes is quite feasible. On the other hand, where the castings are large and supplied either singly or in small numbers, such a procedure is out of the question. Further, the shape and size of castings, in many cases, render them unsuitable for use for mechanical testing unless sample pieces are cut from them. This is frequently a laborious process, and, in order to avoid it, the practice has been adopted in many industries of casting special test-pieces either attached to one of the castings under production or cast separately.

Where Cut-out Tests Fail.

The use of a separately-cast test-piece, whether attached to the main casting or not, has been severely attacked in certain quarters, especially in France, on the ground that the engineer user is not really interested in the properties of a specially-cast test-piece, but only in the properties of his actual casting. Whilst this is, at first sight, a logical attitude, it is largely untenable, and for this reason—the castings as such cannot really be said to have mechanical properties, since such mechanical properties as tensile strength, hardness, elongation, etc., may differ widely from one part of a casting to another. Every founder is familiar with the fact that in the great majority of materials those parts of a casting which have a thin section, and therefore cool more rapidly in the mould, are harder and stronger than parts having a thick section which undergo more gradual solidification. Further, unless a casting is particularly designed and very skilfully made, there is a risk that, owing to "drawing," one part of a casting may become sound and strong at the expense of a neighbouring part, which is left porous and weak. There is also the fact that, owing to variations of detail in melting or casting temperatures and other factors, the properties of one casting may differ appreciably from those of another of the same type and series.

In view of these facts, it must be realised that even if a sample is cut from one of a series of similar castings, or even if an entire casting could be tested, the test still remains that of a sample, and to that extent does not differ appreciably from the testing of a specially-cast sample, provided that the latter has a cross-section which may be regarded as reasonably representative of the casting itself. It is this consideration which appears to weigh conclusively against the demand for tests made on the casting itself or on samples cut from it, so far as reception testing is concerned.

Correlation by Hardness Testing.

In reply to this view it may be said that the engineer requires to know the strength of the material which he uses as it actually exists in various parts of his casting. This is, no doubt, true, but the information cannot and need not be obtained afresh every time a batch of castings is supplied and accepted. If the engineer has before him data of the strength and other properties of different parts of a typical casting of the kind he is considering, properly correlated with tests made on separately-cast test-pieces of suitable size from the same metal as the casting in question, he has all the information which can reasonably be demanded. Given satisfactory foundry practice and supervision, the strength and other properties of the casting will be reasonably proportional to the strength and other properties as found in the separately-cast test-pieces of the same metal.

This correspondence can, if desired, be further checked by the use of an indentation hardness test on any desired number of castings and almost any desired number of points. If the casting shows hardness or indentation numbers which are satisfactorily close to some previously determined standard values, and are also in proper relation to the hardness numbers of the

* Opening Address for a General Discussion held at the Annual Meeting of the Institute of Metals to-day.

separate test-pieces, it will be safe to conclude that the properties of the casting will bear the normal and previously ascertained ratio to those of the separate test-piece. Such a method of using indentation hardness tests for closely correlating the casting to the test-bar has been extensively investigated by Dubi in Switzerland, who has found it useful and reliable. Some fairly obvious precautions are required. It must be realised that a few hardness tests can give no guarantee of soundness and good quality of the casting as a whole. For assurance on that vital point, good foundry practice and careful inspection are the best safeguards. Care must also be taken that the hardness of the casting is not locally affected—at the points where it is to be tested—by the use of chills or other means. Finally, in making indentation tests, it should also be borne in mind that in some castings the crystal structure is apt to be coarse, so that very small indentations may give irregular results.

Where the engineer is concerned in detail with the strength of his casting in regard to any particular system of stresses, that is a matter for investigation, the results of which can be readily correlated with the results of tests on appropriate separately-cast test-pieces. It would seem to be entirely a mistake from the practical and economic point of view to require tests on a number of pieces cut from actual castings in connection with each delivery when the necessary information can be obtained by the methods outlined above. For the purpose of obtaining such information in the first instance, however, and also for investigating the properties of a casting which has failed, the cutting of test-pieces from an actual casting is essential. Where a case of failure has to be investigated it will not as a rule be possible to obtain separately-cast test-pieces. For many such cases, however, the test-pieces which can be obtained from different parts of the casting will necessarily be of very small size. For testing these very small specimens the French investigators who have occupied themselves with this question, including Portevin and Guillery, have done very valuable work in perfecting special testing machines, notably for the application of the shear test. For a time they advocated the general use of these small samples for the reception testing of castings. A full discussion of the subject at the Congress of Zürich, to which reference has already been made, clearly showed, however, that the consensus of opinion among the testing engineers and metallurgists of the world was strongly against the use of these small test-pieces cut from the castings themselves, and definitely in favour of the use of specially-cast test-bars. The author had the privilege of presiding over this discussion and was called upon to summarise its result. This summary is reprinted as an appendix to the present Paper.

Cast-on or Separately-Cast Test-Pieces?

If one accepts the use of specially-cast test-pieces one has to decide how they should be made. The first question is the old one, whether the test-pieces should be "cast-on" or separately-cast. In favour of the "cast-on" test-pieces there is, it seems, only one serious argument—that the casting itself affords a guarantee that the material of the test-piece is derived from the same cast of molten metal as the casting itself. The identity of origin, however, is sometimes interpreted as meaning "identity of quality," but such identity is by no means certain. Where the "cast-on" test-piece is merely a relatively small projection on the surface of a large mass of metal in the casting, identity, or at all events close similarity with the material of the adjacent portions of the casting, is no doubt secured, but the instances where this condition can be fulfilled are relatively few. In the great majority of cases where castings of small or moderate size are concerned, the test-piece constitutes a very considerable projection from the surface of the casting, and may be attached to it only by a thin runner or gate. In such cases the rate at which the test-piece cools may be very different from that of the casting, although one will be influenced by the other—so that anything like a standard rate of cooling of the test-piece cannot be secured. Further, it is quite possible, by the use of chills or other moulding and casting devices, to secure accelerated cooling of the test-piece. There is also the further consideration that by skilful location of the test-piece, and the use of suitable gates and feeders, it is possible to make the test-piece sounder and denser than the casting to which it is attached—indeed, in extreme cases the casting may act as a feeder for the test-piece. It is, of course, clear that practices of this kind would not be contemplated by founders of good repute; also, adequate inspection should make their use impossible. They are, however, automatically eliminated to a great extent by the use of separately-cast test-pieces, and if the latter are suitably standardised, then even the unauthorised use of chills can be entirely prevented. It would not, perhaps, have been necessary to refer to this aspect of the question were it not that the principal argument in favour of the "cast-on" test-piece turns upon a similar point—that of automatically securing the identity of the metal in the test-piece with that of the casting. If the honesty of the founder and the thoroughness of inspection can be relied on to prevent abuse with the "cast-on" test-piece, the same applies to the separately-cast bar.

Standardised Methods Advocated.

If the separately-cast test-bar be adopted, one has to decide on the manner in which it is to be produced. Here it is suggested that the facility of standardisation is most important. Every founder knows that in the majority of metals and alloys different results can be obtained from the same heat by casting test-bars vertically or horizontally and under different conditions as regards head of metal and sizes of gates and risers. At the present time, widely different methods in these respects are used by different founders, even when working with identical or similar alloys, and the real meaning of the requirements of a given specification therefore differs with different makers—a highly undesirable state of affairs. It is for this reason and for the purpose of securing test-bars which should produce identical results wherever made, that a chill-cast test-bar has been specified for many non-ferrous alloys. There are, of course, certain materials in which the use of a chill-cast test-bar could never be contemplated. Cast iron is obviously one of these. Even in other alloys—such as the light alloys of aluminium—where the chill-cast bar has been in use for many years, its employment has been severely criticised.

The main grounds of this criticism are that the chill-cast test-pieces give test figures which are very different from those of the sand castings for which they stand, and that these figures—and especially the statement of them in the specifications—are misleading to the engineer who requires to know the strength of his actual castings. The answer to these contentions is that the intelligent engineer-designer will surely know a great deal more about the material he proposes to adopt for a given purpose than the bare data which are included in a specification. If he does not, the fact—already mentioned above—that the properties of a casting, unless it is of the simplest shape, vary widely from one part to another—would invalidate any inferences he might draw even if the specification tests were made from test-pieces cut out of the casting itself. On the contrary, the correlation of the properties of various typical parts of a given type of casting with the test results obtained from the same alloy when cast into a standard test-bar, whether sand or chill, is a perfectly practicable and necessary thing if the casting is to be intelligently designed and used. It may, however, be pointed out that in many castings of complex shape it is extremely difficult, even for the most skilful engineer, to calculate the working stresses with any accuracy, nor is it usually necessary or desirable to cut down the dimensions of stressed castings to an excessive extent unless extensive experience indicates that a valuable saving of weight is possible. Even when this is done, however, the really essential point in accepting any given casting or batch of castings is to be sure that the quality of the metal or alloy used for making them does not fall below a certain well-established standard of quality. If this is secured, then good foundry practice and good inspection will ensure that the castings also do not fall below the previously accepted standard of quality. From this point of view—and possibly it is the most rational view of the whole question—the object of the test-piece for reception testing purposes is to determine the quality of the metal that has been used for pouring the casting. For this purpose, in a great many alloys, the readily standardised chill-cast bar affords the simplest and best means.

The Problem of Light Alloys.

It has already been pointed out, however, that there are a certain number of alloys to which the chill-cast test-bar is not applicable, and recent progress in the knowledge of alloys has led to a recognition of the fact that exceptional conditions of this kind are found in a much larger range of materials than had previously been suspected. At the present time this development has taken place mainly in the light alloys of aluminium in which two distinct types of difficulty have arisen in the use of the chill-cast test-bar. The first and most general of these relates to the greater attention which is now rightly given to the gas-content of light alloy castings. In sand-castings cooled at ordinary rates the presence of gas makes itself felt—as is now well known—by the occurrence of pin holes or other types of small cavities, accompanied by a very appreciable loss of strength and other undesirable features, such as difficulty in securing a good finish on machining. When an alloy containing sufficient gas to produce defects of this kind in a sand-casting is cast into a chill mould, however, the gas appears to be retained in solution, or, at all events, it does not make its presence visible in the chill-casting and does not appreciably affect the tensile-test results obtained. The consequence is that a chill-cast test-piece can no longer be regarded as affording a true index of the quality of the alloy, and the abandonment of the chill-cast test-bar in favour of a standardised sand-cast bar becomes inevitable.

Incidence of "Modification."

A second factor of the same kind, although as yet of more limited application, arises from the phenomena of "modification" which occur mainly in the aluminium-silicon alloys. In these materials it is of primary importance that the test-piece should definitely show whether the alloy as poured into the castings was properly "modified." In a chill-cast test-piece, however, a properly modified material and one which is quite unsatisfactory from this point of view may give very similar results, whilst a suitable sand-cast test-bar distinguishes clearly between them. Here, again, the adoption of a sand-cast test-bar is necessary.

A Standardised Sand Mould.

The principal difficulty which has hitherto weighed against the adoption of sand-cast test-bars has been that of securing standardisation. Recently, however, investigations which were begun in the first instance at the speaker's suggestion in the Metallurgy Department of the National Physical Laboratory, and have since been extended by the co-operation of manufacturers and of other institutions, have shown that a simple form of sand-mould could be specified which can be reproduced easily in any foundry and which gives reproducible results. The details of these investigations will, it is to be hoped, be published in due course by those who have carried them out, so no more will be said about them

here other than to indicate that the standard mould which has been suggested is for a cylindrical bar with a conical "feeder-head" at the top, rammed in sand in a cylindrical steel tube of specified size, the bar being poured with the mould standing freely in air and inclined at a specified angle. Although intended in the first instance to meet the needs of aluminium alloys, it may prove possible to adopt a standard sand-cast test-bar of this type for a very wide range of alloys. The cylindrical test-bar can, of course, be specified of various diameters, if desired, to accord with the section of the castings under production.

The question of the testing of castings is not, however, settled when one has decided—if one does so decide—to adopt a separately-cast standardised sand-cast test-bar, since it still remains to be agreed what tests are to be applied in order to ascertain the "quality" of the metal. In non-ferrous alloys it is conventional practice to specify as a rule a simple tensile test in which ultimate stress, proof stress, and elongation per cent. on 2 in. are determined. In the case of cast iron, whilst tensile tests are widely used, some form of bending test is also specified, with a measurement not only of the "modulus of rupture," but also of the deflection. In the case of the highly ductile non-ferrous alloys of the brass and bronze and similar types, the measurement of elongation is a sufficient measure of one kind of "ductility," and the use of a bend-test is scarcely required. It is a different matter, however, with many of the casting alloys of aluminium, in which the elongation is rarely as much as 3 per cent. The speaker has long considered that the measurement of these small elongations on fractured test-pieces, where an error of the order of 2 per cent. is quite easily made, is unsatisfactory. None the less, the fact that an alloy does show a small degree of ductility is important in these alloys just as it is in the case of cast iron, and he has therefore recently suggested the adoption of the bend-test with a deflection measurement for ascertaining the ductility of certain cast-aluminium alloys in place of the specification of any elongations lower than 5 per cent. The method of applying the bend-test to test-bars of light alloys requires some investigation, which has, it is thought, been begun, and it is very much to be hoped that in the near future this more satisfactory way of testing cast light alloys for a small degree of ductility may be adopted. It is, probably, a case where the non-ferrous industries have something to learn from the practice of the ferrous, and no doubt there are instances of the converse.

Tensile Testing has Limitations.

It is not proposed to enter here into the much wider question whether tensile tests, supplemented by bending tests or otherwise, furnish the best possible data as to the "quality" of a casting alloy. Since the stresses under which castings are used are frequently other than tensile, tests of this type can be regarded only as more or less conventional "tokens," but the fact that they have been in use for a very long time, and that, in consequence, the data which they have given have become correlated with lengthy experience, gives to these tests a weight which they would not intrinsically possess. On the other hand, one will be wise if one recollects that a few tensile tests do not constitute an exhaustive examination of the properties or qualities of any material, whether cast or wrought. The argument is sometimes used that, provided that his product possesses the required mechanical properties, a manufacturer should be left entirely free as to the raw materials used, the chemical composition adopted, or the method of manufacture employed. If one could really measure, in every case, the "mechanical properties" which one actually requires, this argument might hold, but, in fact, one does not and cannot do this. A few samples are tested and reliance is placed on the uniformity of the material—and here one is entitled to require the manufacturer to use such methods and such materials as are known to favour uniformity of product. Again, in the small number of samples examined, one tests a certain few physical properties—usually tensile strength and elongation. Experience has shown how far one can go in relying on these as a guide to the "strength" of the material for the uses to which it is put, but this correlation is limited, and one can rely upon it only where the materials are closely similar—any serious variation of composition or method of manufacture, or even of raw materials used, might introduce factors which one is unable to estimate. Considerations of this kind have frequently stood in the way of anything but the most cautious adoption of promising new alloys; they would stand in the way of the use of materials corresponding with existing specifications so far as tensile tests are concerned, but freed from all other restrictions.

These considerations, which have sometimes been lost sight of when specifications have been discussed or criticised, suggest that in order to improve specifications, and thereby allow of the improvement of materials, while at the same time permitting more economical methods of production, much further knowledge is needed. The improvement of methods of testing is of first-rate importance, both to the manufacturer and the user. If one can render the methods of testing more completely reliable from the user's point of view, one will be more readily able to admit quicker and cheaper methods of production or the use of more economical raw materials by the manufacturer. At present, apart from the methods of mechanical testing which have been discussed above, there is little but chemical analysis and the determination of density that can be readily applied. Other methods of testing have yet to be developed. The use of magnetic and X-ray methods has already been mentioned, and systematic microscopic examination is also coming into use in some cases, although its possibilities have not been fully exploited in this country. The measurement of electrical conductivity is a possibility of the future; as yet it is used mainly in the scientific study of alloy constitution, but the scientific method of to-day frequently becomes the workshop method of to-morrow. This possibility also applies to other methods, such as the measurement of the velocity and intensity of transmission of sound, which is being developed in the physical laboratories. Nor need the maker of castings fear these things. If they teach engineers to test their products more thoroughly, they will not necessarily lead them to make higher demands. After all, the products which industry now supplies in the great majority of cases meet the demands of service. Those demands will, doubtless, continue to rise as both engineering and metallurgical practice continue to improve. Progress in methods of testing, however, is likely to give the manufacturer greater freedom, since it is often found that some of the conditions on which users insist are unnecessary restrictions on the manufacturer. The close interdependence of engineer and manufacturer is nowhere more apparent than in this field of testing, and especially the testing of castings. The economic production of good castings is of importance to both, and the improvement of methods of testing is therefore a matter of common interest.

APPENDIX.

The New International Association for Testing Materials. Zürich Congress, September, 1931.

The Testing of Cast Iron.

The following statement has been prepared by the President of Section A, in accordance with the procedure approved by the Permanent Committee of the Association. It is intended to represent not the personal views of the President, but the best estimate which he has been able to form of the general conclusions to be reached from the Reports submitted and the discussion which took place at the Zürich Meeting. In formulating this statement, the President has had the great advantage of having before him reports, prepared at his request immediately after the conclusion of the discussion, by Messrs. Benedicks, Dubi, Pearce and Portevin.

President's Summary.

In the Reports submitted and in the discussion upon them, two somewhat different viewpoints emerged. On the one hand, the use of separately-cast test-bars to be tested either in tension or bending or both was advocated. This was the view of the great majority of those present, and it corresponds with present practice in Belgium, Czecho-Slovakia, Germany, Great Britain, Holland, Switzerland and the United States of America. On the other hand, the use of very small test-pieces, trepanned from the actual casting and tested in shear, with a supplementary bending test also on a very small bar, was advocated by the French representatives, and this method of testing is favoured also in Italy and Spain.

Whilst these divergent opinions have not, perhaps, been entirely reconciled as the result of the discussion, a considerable measure of agreement has emerged. It has been recognised that the separately-cast test-bar is the only practical means for controlling the quality of the liquid iron which is used in the production of castings. By many, it is further considered that this control is sufficient for the acceptance of the castings themselves, and that it is possible by establishing a relation, based on Brinell or other hardness tests, between the properties of the test-bar and of the casting itself, to arrive at a sufficient knowledge of the properties of the casting. With regard to the claim that the properties of the casting can be tested only by testing portions taken from the casting itself, it was pointed out that these properties vary widely in different parts of the same casting and may even vary, to a considerable extent, between one casting and another made from the same metal and to the same pattern. In these circumstances, the test-piece, whether large or small, cut from one casting out of a series, does not differ in principle from a separately-cast test-piece. The only difference is that in the one case the test-piece is cut from a casting made to the same pattern as those to be accepted, while in the other a simplified form of casting (test-bar) is employed. Where the dimensions of the separately-cast test-bar are adjusted so as to correspond approximately with the wall thickness of the casting under test, this difference may be regarded as negligible.

On the other hand, where only a small number of similar castings are made, and it is possible to take samples from each of them, so that the uniformity of the material from one casting to another can be investigated in this way, or where it is desirable to explore the properties of different portions of the same casting, or where it is important to obtain a specially close correlation between the properties of a particular part of a casting and the results of a separately-cast test-bar, the use of small test-pieces, suitable for shear testing, as advocated by the French representatives, is recognised as having very great value.

The position may be summed up briefly by saying that, in the opinions of the great majority of those who took part in the discussion at Zürich, the use of a separately-cast test-bar, to be tested in tension and bending, is to be regarded as satisfactory and sufficient for the majority of industrial purposes, but that for the exploration of the properties of various parts of castings, and for the study of variations from one casting to another of the same type, and also for the investigation of castings which have failed in service, the small test-piece, cut from the casting itself, should be adopted.

The Use of Pulverised Fuel and Pulverisers in the Foundry.*

By P. Howden. A.I.E.E.

The object of this Paper is to outline what it is thought are good reasons for investigating the possibilities of pulverising plant in the foundry. It is proposed to describe general applications and to point out the considerations to be borne in mind when applying pulverising plants to foundry practice. Each foundry has its own individual requirements, necessitating in some cases special methods of production, but in almost all foundries, pulverising plants can, it is thought, be installed to advantage.

Coal Suitable for Pulverised Fuel Firing.

It is possible to burn any known coal when pulverised, and perfectly satisfactory results on steam boilers are being obtained with refuse from colliery washeries, containing up to 50 per cent. ash. For melting iron, however, it is desirable to use a coal having low ash content, say, not exceeding 8 per cent., low sulphur content, and with a calorific value of 13,500 B.T.U. or over. Such coals are obtainable as smalls at prices between 10s. and 18s. per ton.

For annealing furnaces and for core ovens any bituminous coal of reasonable quality can be used, but if for commercial reasons a coal of high ash content is likely to be adopted, then particular care should be taken in designing the flues to permit quick and easy cleaning out of dust. It should always be remembered that the wear on the pulveriser grinding elements is greater when handling coal having high ash content.

Pulverisers, Combustion and Burning Equipment.

The art of burning coal in a pulverised form is now a proved commercial and practical proposition, but to obtain the most efficient results each application needs to be carefully arranged. The principal factors which have to be taken into consideration when designing any installation are as follow:—

A.—Fineness of Grinding. This must be uniform with everything passing a 40-mesh sieve, and from 75 to 90 per cent. passing a 200-mesh sieve, depending on the application under consideration. Low-volatile coals and anthracite must be ground to not less than 85 per cent. through 200-mesh to obtain complete combustion. In spite of everything which has been claimed to the contrary, complete combustion cannot be obtained with any coal if the fineness of grinding is less than 75 per cent. through 200-mesh, and many disappointing results have been due mainly to this fact not being known, or, if known, ignored. There are times when it pays to grind coarse, such as on very large cement kilns, where it is necessary to delay combustion to obtain a long flame, but for metallurgical-furnace work the finer one grinds the better, within commercial limits. For foundry use, therefore, a pulveriser is required which will grind finely *and which will maintain this fineness always*, whether the grinding elements are worn or new.

B.—The pulveriser must be definitely reliable and capable of working satisfactorily when delivering any volume of primary air that burning conditions call for.

C.—The raw-coal feeder must be infinitely variable and calibrated to give accurate feed for any given setting over a wide range, and also should be capable of being operated from one handle or handwheel.

D.—The secondary air must be under complete control, preferably preheated to as high a temperature as possible, and the control should be on the cold-air intake to the air heater, so that the same weight of air is always given on any particular setting. When melting steel a secondary air temperature of 500 deg. C. should be aimed at to give high efficiency and quick melting.

E.—The combustion space must be suitably proportioned for the duty called for and the burners so arranged as to allow of combustion being completed in the proper working zone. The rate of heat release may be as low as 6 B.T.U. per cub. ft. per sec. and as high as 40, but when working at a high rate of heat release it is essential to have fine grinding and preheated air to obtain the best results.

F.—The burner must be designed for the particular application in hand to give a soft, well-diffused heat for annealing furnaces, a long licking flame for core ovens, a concentrated heat for melting and so on.

G.—Ash removal should be carefully arranged for and proper steps taken to ensure that practised results are not interfered with due to accumulation of ash whether in the flues or on the work.

These, then, are the main conditions to be recognised on all installations. There is nothing really difficult about them, but the plant must be designed as a whole, taking all these points into consideration.

Melting Iron by Means of Powdered Fuel.

The cupola has held its position as the most popular appliance for melting iron by reason of its comparative low first cost and simplicity, and, by careful operation and selection of coke and metals, reasonably good results are obtained. Modern industrial conditions, however, are setting new standards, and it is becoming the practice for users of iron castings to demand uniform quality and superior physical properties, which are difficult to maintain with cupola-melted iron under average production conditions, since perfect control of the combustion and melting conditions and exact predetermination of the losses in the cupola cannot be achieved. Powdered-fuel fired furnaces permit perfect control of the combustion, exact predetermination of losses, use less fuel of a cheaper grade and require less labour to operate.

Some years ago extensive tests were made in Germany with a view to supplying powdered coal to the ordinary cupola. It was found that if powdered coal was blown into the cupola at, say, three points above the tuyeres, the coke charges could be reduced very considerably and the melting time also reduced. Several cupolas were altered to this form of firing and apparently gave satisfaction and as much as 40 per cent. reduction in fuel costs, together with a superior metal, were claimed. Although patents were taken out, the system did not become popular, possibly because the rotary reverberatory furnace was being developed about the same time.

Air Furnaces.

Quite a large number of hand-fired reverberatory air furnaces have been in use for many years for melting iron, particularly in malleable foundries in the United States. This type of furnace, when hand-fired, suffers to some extent from the difficulty of obtaining control of combustion conditions. Furnaces of this type arranged for firing by pulverised fuel have, however, been in operation for more than ten years, producing economically metal of excellent quality, and it is predicted that within the next few years this type of furnace will be exclusively fired by pulverised fuel, as the advantages of this form of firing are so great.

Rotary and Rocking Reverberatory Furnaces.

This type of furnace has come to the front, and its advantages have been described in recent Papers. It is regrettable that one of the pioneers, Carl Brackelsberg, who spent many years developing this type of furnace, met an untimely death last year. The author's firm has recently supplied the pulverising equipment for two 15-ton Brackelsberg furnaces for melting grey iron. These are the largest rotary iron-melting furnaces installed in this country.

The Brackelsberg furnace differs from other rotary and rocking furnaces inasmuch that it has been made comparatively long in relation to its diameter, and the drum shell is carried in a cradle which enables the drum shell to be tipped. This arrangement has the advantage that the molten slag can be easily and quickly removed from the furnace at the end of each melt by tipping the furnace, the slag running out of the flame discharge opening.

The furnace is charged while the drum shell is in the inclined position, and with proper handling facilities the largest-size furnace can be slagged-off and recharged in 20 min. ready for the next melt. This furnace can be worked on either bituminous coal or anthracite coal, the secondary air being heated to 600 deg. C., the primary air only being heated to about 150 deg. Fah., enabling bituminous coal to be carried by the primary air into the furnace without distilling the tars or volatile matter.

The Sklenar rocking furnace is of unique design and combines the advantages of the rotary furnace and the fixed air-furnace. It is designed to rock to and fro, and this action is claimed to give a perfectly-mixed molten metal. The arch is of the suspended type, removable in sections, which facilitates relining. A recuperator is fitted to the furnace exhaust, thereby ensuring high efficiency of combustion. The furnace burns bituminous coal purchasable in any part of the country at a relatively low price. The coal-pulverising plant which has been supplied for this furnace is the direct-firing ring-mill plant previously described in this Paper, in conjunction with a special burner designed by Saml. Hodge & Company, Limited, London. The whole equipment takes up little floor space and is simple to operate.

The Sesci furnace is of the rotating type employing a special burner in which the whole of the air for combustion is supplied from one blower. With this furnace the flame is started on bituminous coal, and when the furnace has become well heated bituminous coal is shut off and the melting proper carried out by anthracite coal. It has been illustrated several times in the foundry Press.

Advantages of Using Pulverised Fuel.

The advantages of using pulverised fuel for melting iron ore are as follow:—*A.*—Control of combustion and predetermination of melting losses. The melting is under perfect control and the fuel feed can be adjusted at any time during the melt. The exact amount of air required to obtain proper combustion can be obtained at all times and the air and fuel control handles arranged together at any convenient point on a control board. Due to the possibility of accurate regulation it is easy to predetermine the losses in a powdered fuel fired furnace, and this enables the same product to be obtained repeatedly for any composition of charge. Thus a uniform high quality of melted metal is assured. When installing pulverised fuel melting plant it is essential that the proper facilities are provided for easy and accurate control of the fuel and air.

B.—Reduction in Melting Costs. Since coal suitable for pulverising is in most districts far cheaper than best quality furnace coke, the cost of fuel is reduced, whilst in addition the amount

* A Paper read by Mr. J. Davis on behalf of the Author before the Sheffield Branch of the Institute of British Foundrymen, Mr. G. C. Castle presiding.

of fuel required per ton of metal melted is very low, and with rotary melting furnaces fitted with recuperators the coal consumption when melting grey iron is only 12 per cent.

C.—The metallurgical advantages of powdered fuel have been described in different Papers recently, and are generally acknowledged, and it is not necessary to repeat these arguments except to say that rotary or rocking reverberatory furnaces appear to offer the greatest all-round advantages, although for certain purposes the older types of air furnace may continue to be used in spite of the higher fuel consumption necessary.

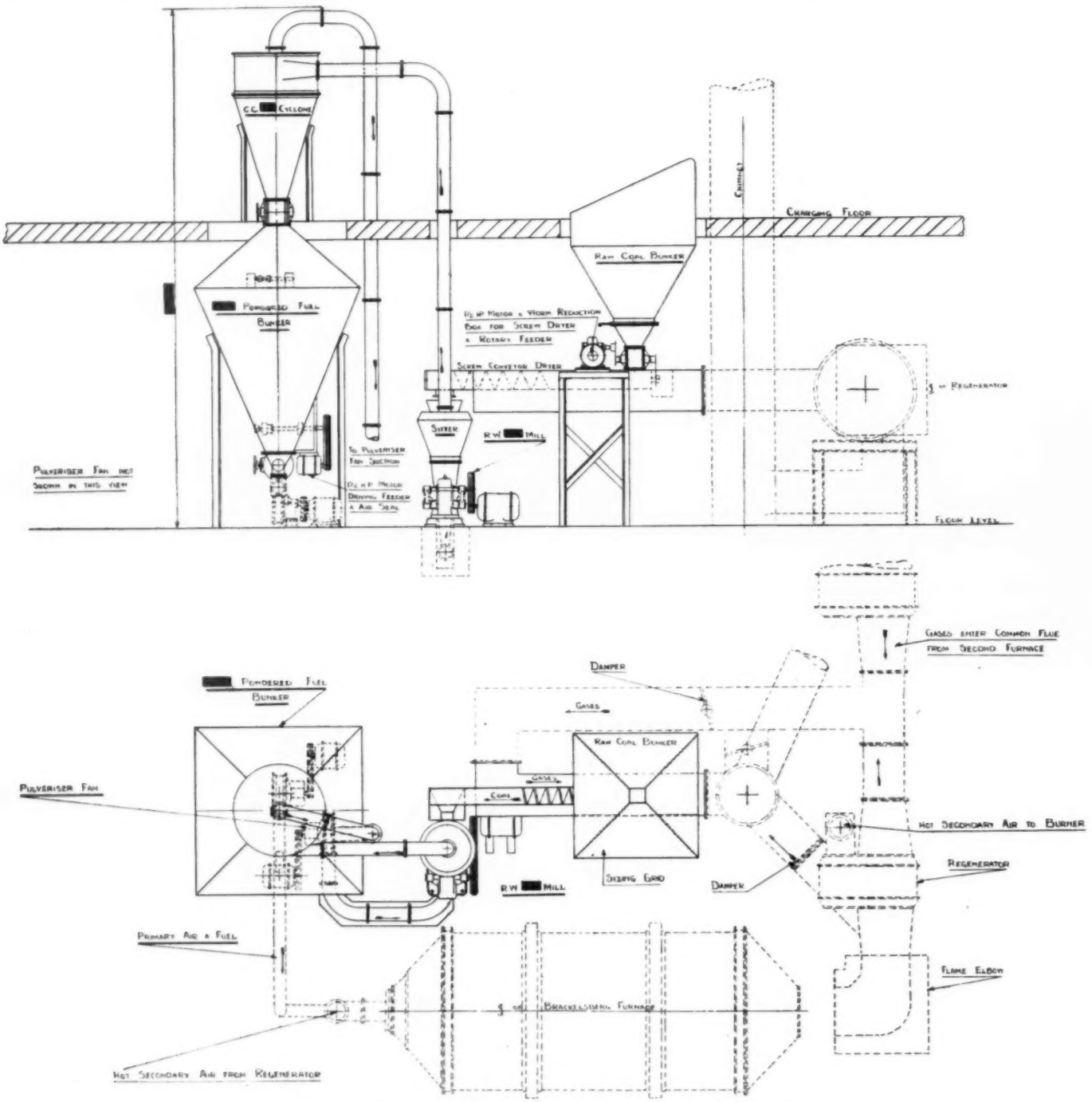


Fig. 1.—A Typical Modern Pulverised-fuel-fired Melting Plant.

Pulverising Plant.

In order to obtain satisfactory results, the pulverising plant must be perfectly reliable, require but little attention in service, and be properly designed to suit the combustion equipment it is to work with. Many of the early difficulties with pulverised fuel firing were directly due to the lack of appreciation of these points, but with a modern plant designed by experienced powdered fuel engineers, the operation is as simple and reliable as oil fuel firing.

Systems of Powdered Fuel Firing.

The oldest system of pulverised-fuel firing is what is known as the storage or bin and feeder system. In these systems the pulverising plant delivers the powdered fuel to a storage bin from which it is fed according to requirements by means of a feed screw to the primary air pipe leading to the burner. In the early days of pulverised fuel firing, this system was universally adopted because pulverising mills were not considered sufficiently reliable to enable continuous running to be obtained, and because satisfactory means of adjusting the primary air on unit systems had not then been discovered. Except in special cases, there is now no need to adopt the storage system, as perfectly reliable and flexible pulverisers are now available to work on the unit system.

The storage system is more expensive to install, occupies more space, requires more motors, power and attention, than the simpler unit system, and should never be adopted unless there are special and unavoidable reasons for doing so. Another disadvantage of the central system is that the coal and air projected into the burner pipe are never as well mixed as on unit systems, and combustion is not completed as quickly.

The direct or unit system of firing is the latest, most reliable, simplest and cheapest form

of powdered-fuel-firing plant. The author has been a strong advocate of this system, and his firm has originated and developed machines and devices which have proved, in operation, superior in every way to the best plants operating on the storage system. With the unit system, the primary air and powdered fuel are blown by the pulveriser fan direct to the burner, and all powdered-coal bins, cyclones, air filters and separate primary air fans are eliminated. Several types of machine are available to work on this principle, and the British Rema Ring Mill pulverising plant, shown in Fig. 1, is typical of the best of them.

The British Rema Ring Mill Units System.

This machine (Fig. 2) comprises a ring mill coupled up to a classifier and primary air fan by means of piping and suitable shutes, with an adjustable automatic feeder to regulate the raw coal feed, and the machine feeds, dries, grinds and conveys the coal along with the requisite primary air to the burner. One of the difficulties which used to be encountered in all unit systems was arranging the fan to give the correct amount of primary air to the burners. The author has overcome this difficulty by adopting a simple method, which is known as bye-pass control, and for which patents have obtained in most countries.

This method consists in providing a branch pipe controlled by a valve connecting the burner pipe and pulveriser air inlet, and shunting back that proportion of the air not required by the burner. This enables the correct constant quantity of air to be drawn through the pulveriser at all times whilst allowing the volume of primary air delivered to the burner, or burners, to be set to that found on site to be best for combustion conditions. Thus, by a simple means, one of the greatest difficulties of unit firing has been overcome.

The raw coal is fed to the mill by means of a feeder, which may be of the band conveyor, or reciprocating, or rotary type. In every case the rate of feed can be varied by a hand wheel or lever actuated from the control board, and calibrated in lbs. per min. or lbs. per hour. It is most important, as has been shown, to have accurate and easy control of the feed in order to maintain exact control of the combustion conditions.

The raw coal is delivered by the feeder into the vertical pipe behind the mill, and is lifted by air current up to the classifier, and dried by the air it is being lifted. The oversize particles are rejected to the mill for grinding, and any fine particles pass out via the classifier to the fan and burner. Without going into full details, what occurs in practice is that a steady and regular supply of coal is delivered to the burner, or burners, in accordance with the rate of raw-coal feed.

Notice that the whole action is automatic. The raw-coal bunker is filled with coal of, say, 1-in. cube and under, and no attention to the pulveriser during running is needed. This machine is of particularly robust construction, and requires practically no attention except renewal of the ring and rolls, say every 8,000 hours, which will be every two years on ordinary melting furnace operation, and renewals of the fan blades and segments say every 4,000 hours.

This machine is very adaptable and gives equally good results on both large and small installations, and its advantages are such that it is particularly suitable for use in the foundry. Its features are as follow:—

(1) No attention required during running.

(2) The wearing parts are so thick and heavy, and the rate of wear so slow, that the machine requires no repairs or replacement parts for two years on the usual foundry applications. All bearings are situated in dust-proof housings outside the mill casing.

(3) The volume of primary air can be set to suit exactly the burner or furnace on site due to the patented bye-pass control.

(4) As the fan is a separate unit and not built into the pulveriser, it can easily be made suitable for low-pressure, medium-pressure or high-pressure burner, and many machines are working in conjunction with burner pressures from $\frac{1}{2}$ in. w.g. to 14 in. w.g.

(5) The coal feed is easily regulated at a definite rate for any given setting. This is a most important point and perfect results on unit-fired plants are impossible unless accurate control of the raw coal is obtained.

(6) The fineness of the powdered fuel remains constant independent of wear on the grinding elements, and the machine produces powdered coal to a fineness of 80 per cent. through 200 mesh consistently.

(7) There is no falling-off in output or fineness, or increase in power consumption as the grinding elements wear.

(8) The machine is extremely flexible and answers quickly to changes of feed.

(9) The plant is almost noiseless in operation and free from vibration.

(10) The primary air and powdered fuel are intimately mixed before reaching the burner, ensuring the best combustion conditions. This particular machine has been thoroughly proved out for firing rotary and rocking furnaces both on the Continent and in England, and twelve such furnaces are being fired with this machine in England and in Germany. The author recently saw one of the earlier machines in Germany at Vereinigte Schlussel Fabriken, which had been constantly in use on one of the first Brackelsberg furnaces since 1928, making three and four melts per day and giving very satisfactory results. The later machines have many detailed improvements. Other types are the Swanscombe mills, the Brimsdon machine and the ball-mill unit firing.

The British Rema Ball-Mill Unit Pulverised Fuel Firing System.

This particular plant operates in general principle in a very similar manner to the Rema ring-mill plants, the air circulation classifying and feeding and conveying of the coal being carried out in exactly the same manner. This machine, in common with all other ball mills, is essentially a mill for high capacity and output, say 3 tons per hr. and over, and offers marked advantages when applied to large cement kilns and steam boilers.

In the author's opinion, ball mills as a class are not the best machines for direct firing metallurgical furnaces, for the sole reason that they do not respond quickly enough to changes of feed, and consequently do not permit sufficiently close regulation of combustion conditions. For operation on the central system, and for direct firing large boilers and kilns, however, the Rema ball mill, shown in Fig. 3, has many important advantages.

The Ball Mill for Bin and Feeder System.

The machine will economically produce superfine coal, and requires no separate dryer, as the moisture is extracted from the raw coal by the conveying air as it is being lifted up to the vertical ascension pipe, and consequently, when wet coal is fed to the pulverising plant, it is dried before it reaches the actual grinding mill. Another feature peculiar to this machine is that the mill is not swept by air as is the usual practice. The coal passes quickly through the mill and is discharged in a partially-ground condition back into the circulating air, the fines being quickly extracted by the classifier and the coarse material rejected along with the raw feed for further grinding.

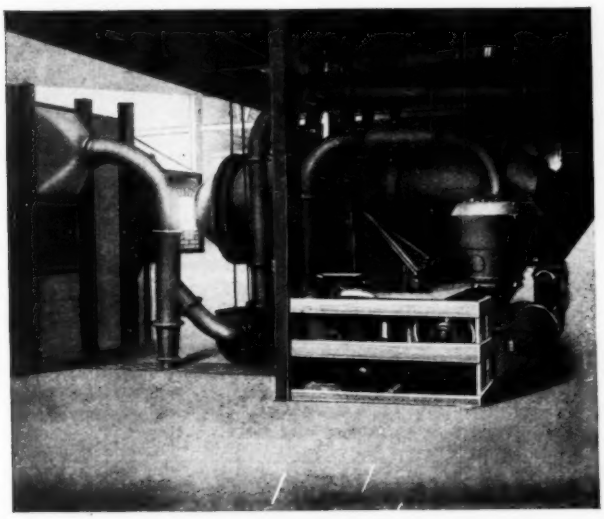


Fig. 2.—A Modern Ring Mill Pulverising Plant.

Fig. 3.—The Ball-mill Type of Pulveriser.

This rapid circulation of the coal, properly dried, through the Rema ball mill enables the fine coal to be extracted as soon as it is produced, and results in a very low power consumption and high output for a given size of mill.

The British Rema Multiplex Pulveriser.

This is a new unit firing plant, specially designed to meet the requirements of small plants where an inexpensive, compact, but reliable machine is required. The machine shown in Fig. 4 is of the high-speed type, and the grinding of the coal is carried out by pure attrition. The author has carried out research work over a period of two years on high-speed mills to ascertain the facts regarding pulverising by high-speed mills; as a result, he found that most of the grinding in all types of high-speed mills is the result of the coal particles being rubbed over each other at high velocity, and that the most efficient results are obtained on a machine having a plain grinding ring against which the coal is swirled round at high velocity and working in conjunction with a classifier. Having ascertained the principle, this was made the basis of a design incorporating all the features known to be desirable as a result of earlier experience on other machines.

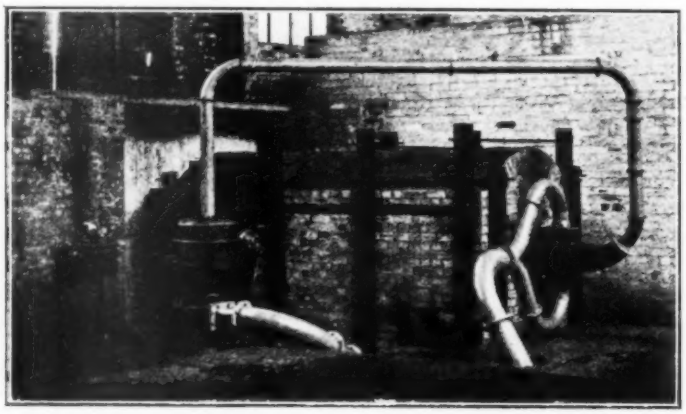


Fig. 4.—The British Rema Multiplex Pulveriser.

The author believes that the design now disclosed meets every requirement of the ideal unit firing plant, and the following details will, he thinks, substantiate this opinion.

(A) The machine is a complete firing-unit driven by one motor, and supplying powdered fuel, primary and secondary air, and automatically feeding, drying, grinding, classifying and conveying the coal to the burners.

(B) The primary air is generated by the grinding beaters themselves, and thus the usual primary-air fan is eliminated.

(C) A compact, but very efficient, classifier is incorporated, this being arranged immediately over the grinding chamber.

(D) The grinding is carried out in a single chamber, and the only wearing parts are a single-liner ring and six beater heads.

(E) The fineness is adjustable between the limits of 75 per cent. through 200 mesh and 85 per cent. through 200 mesh, the adjustment being made by moving the vanes of the classifier by means of a handle situated on top of the classifier.

(F) The fineness of grinding definitely *improves* as wear takes place on the grinding elements. This is a valuable feature peculiar to this machine, as on other high-speed pulverisers the fineness deteriorates as the grinding elements wear.

(G) An automatic feeder is provided, having infinitely variable adjustment. The feed is controlled by one handle, or handwheel, and the control handle may be fitted on the feeder casing or on a control board situated in any convenient position. Adjustment of secondary air can also be provided on the secondary-fan inlet by means of a graduated valve, and this valve can also be arranged to be operated from a control board.

(H) Tramp iron, brass, iron pyrites, anchorite and heavy foreign substances are rejected automatically.

(I) The wearing parts can be replaced in twenty minutes without disturbing the driving shaft and bearings.

(J) The machine is easily arranged to work in conjunction with high-, medium- or low-pressure burners to suit any type of furnace.

(K) In addition to the above features, the mill is very reliable in service, occupies a minimum of space, is very low in first cost, simple in construction, whilst replacements are only required at infrequent intervals, the wearing parts being few and cheap, and easily replaced by reason of the accessible design.

Firing Core Ovens and Mould Driers by Pulverised Fuel.

Little has been done in this country in connection with the drying of moulds and cores by pulverised fuel, although marked economies and advantages are possible by its use, as pulverised-fuel firing has all the advantages of oil firing at a quarter of the cost. The author has recently equipped a number of ovens (Fig. 5) with this form of firing, and although full data are not yet available, the results obtained so far fully justify its adoption.

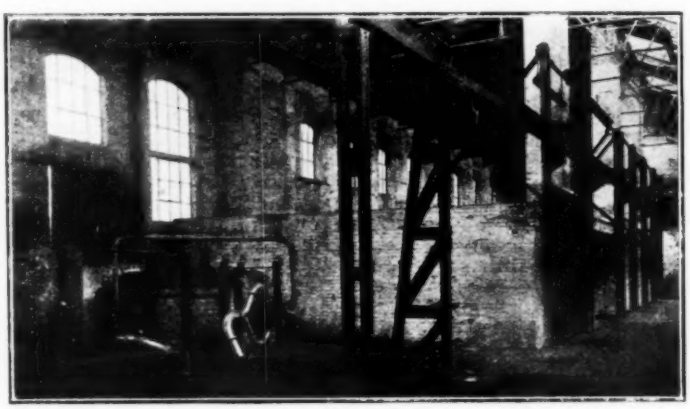


Fig. 5.—Pulverised-fuel Plant attached to a Battery of Mould- and Core-drying Ovens.

Where several ovens are grouped together they can be fired from one small pulveriser on the unit system. A combustion chamber can be arranged at one end of the row of ovens, the hot gases being driven along a single flue running along the back of the row of ovens.

In all cases it is necessary to make suitable arrangements to mix a relatively large volume of air with the hot gases discharged from the combustion chamber. The actual methods used for mixing will vary according to individual lay-outs. The hot gases mix with the air and the temperature of the mixture entering the core ovens is reduced to that found desirable for drying without burning the "skin" of the cores or moulds (say 350 to 400 deg. F.). This arrangement gives a maximum drying effect as the large volume of hot air removes the moisture quickly due to the rapid circulation obtained.

It is, of course, essential to arrange proper chimneys to discharge the moisture vapour to atmosphere to avoid "stewing" or concentration of hot vapour inside the ovens, which retards drying. Further, if the chimneys of ample height and size are used, the air for mixing with the hot gases from the combustion chamber can be drawn in at the rear of the combustion chamber and at other convenient places by chimney draft alone. Apart from this, the ovens, flues and combustion chamber will always be under a slight suction if a good chimney is provided.

The necessity of constant circulation will be at once understood when it is realised that one cub. ft. of air at 350 deg. F. will absorb about 21 grains or 0.003 lbs. of water vapour, and no more, and when the air has absorbed this moisture it should be passed to atmosphere and replaced by dry air. Merely holding the air inside the oven at a given temperature will not dry the moulds.

With pulverised-fuel firing the air flowing to the ovens is raised to the proper working temperature within about an hour of "lighting up," and this temperature can be maintained at a constant value without any attention. With hand firing by solid fuel it is difficult to obtain a constant temperature and frequent attention to fires is necessary.

The fuel required varies according to size of the ovens and the class of mould being dealt with, but about 25 per cent. saving in the weight of fuel used is possible over best hand-firing methods, whilst cheap smudge coal is used, costing no more than 10s. to 15s. per ton in most districts. Unit pulverisers are now sufficiently reliable to permit the plant to be left unattended and a time switch can be installed so that the plant can be left firing the ovens after normal working hours and shut down automatically at a predetermined hour.

Flue Arrangements and Ash Removal.

In the author's opinion underground flues offer no advantage over the end-flue arrangement for firing core ovens, and good circulation of heated air in the ovens has been obtained by careful arrangement of chimneys and of the openings connecting the end flue with the interior of the ovens. With the end flue arrange-

ment it is an easy matter to remove the ash which gradually accumulates on the bottom of flue and also on the floor of the oven. With a bank of six ovens 25 ft. by 15 ft. by 10 ft. the time required for removing ash will be two hours per week. Another advantage of the end-flue is that one or more ovens in one bank can be shut off by simple means without interfering with the circulation on the others. If underground flues are used much more frequent cleaning is necessary, without any advantage being obtained.

The success obtained by firing core ovens by pulverised fuel has resulted in attention being turned to mould-drying, and whilst the author cannot disclose details of the equipment at present, the preliminary results obtained show marked advantages over existing mould-dryers of the hand-fired type and oil-fired type.

Firing Malleable Iron Annealing Furnaces by Powdered Fuel.

The majority of malleable-iron furnaces in this country are hand-fired, using best-quality lump coal at from 22s. to 30s. per ton, and the author knows of many installations where the coal consumption is extraordinarily high, amounting to as much as 2 tons of coal per ton of metal annealed. With pulverised-fuel firing the coal consumption on large malleable annealing furnaces will be 500 to 1,000 lbs. of coal per ton of iron annealed, and on small furnaces from 1,000 to 1,750 lbs. of coal per ton of iron annealed. The coal used for pulverised-fuel firing is smudge, costing from 9s. to 15s. per ton.

The cost of labour for firing is practically eliminated with powdered-fuel firing, which results in a continuous saving, and there is, in addition, a big saving in connection with the life of the "cans," "boxes" or containers, in which the castings to be annealed are packed, as the containers have at least twice the life when used in pulverised-fuel-fired annealing furnaces, as scaling is reduced. The reduction in scaling is due to two causes. First, the pulverised-fuel furnace can be worked with very little or no excess air, giving a neutral or reducing flame. The hand-fired furnace, however, must have considerable excess air in order to enable combustion to be completed, and an oxidising flame occurs inside the furnace.

In the pulverised-fuel furnace for annealing malleable, the fine ash particules are found to adhere to the surface of the containers, forming a protective coating which protects the boxes without interfering with the metallurgical process. It has been definitely proved, on actual installations both in this country and in America, that the savings in fuel charges, labour costs, and life of containers will, in many cases, pay for the pulverising plant in two years, and all firms manufacturing malleable iron should investigate pulverised-fuel firing of their annealing furnaces, as serious savings are possible.

Many of the malleable-iron annealing furnaces in use in this country are of small size, and this factor has prevented pulverised fuel being applied to such furnaces on account of the high capital cost of the necessary pulverising equipment, especially when of the storage or bin-and-feeder type, and the practice of using one pulveriser per furnace when unit systems were adopted. It is now, however, possible to fire, say, three small furnaces from one small-size high-speed unit pulveriser of the type described earlier in this Paper. This pulveriser can be fitted with a special patented distributor box to deliver the powdered fuel equally to six burners, say two for each furnace, and two, four or six burners can be in use, as working conditions warrant. Further, it is now possible to obtain proper combustion with burners using only 30 lbs. of fuel per hour. Very little alteration is necessary to most furnaces when applying powdered fuel, and three furnaces, each of a size, say, 10 ft. by 6 ft. by 8 ft., can be converted and save £350 the first year.

Mixing of "Blacking" Core Bonding, Solutions, etc.

The author has applied a high-speed wet pulveriser to the mixing of foundry "blacking" and core-bonding solutions. The machine is quite novel and is protected by British and foreign provisional patent applications. The machine consists essentially of an emulsifier coupled to a receiver or tank by piping. The materials to be mixed are placed in the receiver, liquids being poured in first. The emulsifier circulates the liquid through the discharge pipe back to the receiver. As the solids are added to the liquid they are intimately mixed in their passage through the emulsifier along with the liquids.

After the materials have been placed in the receiver, the machine is left running for about twenty minutes, the mixture circulating many times through the emulsifier. By this means a perfectly uniform mixture or emulsion is formed and the machine will produce economically perfect mixtures, even in paste form, which will not easily settle out. A valve is provided on the container to allow the mixture to be drained off as required for use. About 40 gallons of uniformly mixed "blacking" can be produced for labour and power charge of less than 1s.

The British Industries Fair.

The official visit of the Institute of British Foundrymen and the British Cast Iron Research Association was paid on March 1 to the British Industries Fair, and a large company assembled to have luncheon with the Fair Management Committee, over which Mr. C. Holland Harper, of John Harper & Company, Limited, Willenhall, Vice-Chairman of the Management Committee of the Fair, presided. After the luncheon Mr. Harper welcomed the representatives of the organisations present, and called upon Mr. H. B. Weeks, F.I.C., Chairman of Council of the British Cast Iron Research Association, to respond on behalf of that Association.

Mr. Weeks expressed the appreciation of the visitors for the hospitality they had received and the opportunity they had had of meeting one another under such pleasant circumstances and of seeing the Fair exhibits. Mr. Weeks thanked the Chairman for his kind references to the British Cast Iron Research Association, of which his (Mr. Harper's) firm had for a very long time been a keen supporter. He went on to point out that the Association was greatly indebted to the Government through the Advisory Council of the Department of Scientific and Industrial Research, for very generous treatment in respect of grant to counteract the difficulty of increasing subscriptions to the desired figure during the present depressed period. He stated that the Government were entirely satisfied with the work of the Association and the progress made, but they were very much concerned over the lack of support from the industry. The speaker felt that it had mainly arisen as a consequence of the trade depression and anticipated that with a revival in trade the goodwill which the Association enjoyed would be shown in the increased industrial support which was essential to its continuance. He pointed out that there were in the Fair over 1,000,000 exhibits and more than 2,300 exhibitors, and stated that he had never seen a more optimistic spirit than had been shown on the present occasion.

The Chairman then called upon Mr. A. Harley, of the Daimler Company, Limited, President of the Institute of British Foundrymen, to respond on behalf of the Institute, and Mr. Harley did so in a very felicitous speech. After the luncheon the visitors resumed the inspection of the exhibits.

Catalogues Received.

Refractories.—A small cardboard folder has been used by General Refractories, Limited, Genefrax House, Sheffield, for outlining the properties of "Insulite" bricks. They are based on a National Physical Laboratory report, and are elaborated to show their practical significance. The cover is particularly effective, as it shows a section through a firebrick—"Insulite"—red-brick composite wall, with a graph superimposed showing a fine temperature arrest, due to the incidence of the heat-insulating material.

Motors.—The Metropolitan-Vickers Company, Limited, Trafford Park, Manchester, have sent us two publications dealing with the subject of motors. One is a folder—a type of publicity for which we confess a personal prejudice, which dimensions, prices and outlines a number of typical applications of a comprehensive range of fractional h.p. motors. We confess that in this case the folder does not have the appalling habit of presenting its matter upside down, nor inhibiting a doubt as to whether each section has been inspected. Our readers will find this well worth while filing, as so many jobs come along nowadays requiring tiny motors. The second is an 8-page pamphlet, which covers the subject of single-phase motors and starters. Squirrel-cage, slip-ring and repulsion-induction types are described and illustrated, whilst on pages 5, 6, 7 a very wide range is priced. We just wonder whether or not a telegraphic code ought to have been included.

Publications Received.

Southampton Docks. Compiled by H. N. Appleby and published by the Southern Railway, Dock Manager's Office, Southampton.

Turning the pages of this 200-page, excellently-illustrated handbook, we were reminded of the time when we were constantly travelling to the Continent by the Southampton-Havre route. We have tried every sea route available, but because of the courtesy invariably extended to us by the staff along this route, it still remains our favourite means of reaching Paris. This, however, is quite beside the point, for the object of the book is to place in the hands of manufacturers a concise statement of the advantages of Southampton as a port from which to despatch goods, the charges which are made for loading and unloading, for storage, the services it maintains with foreign ports, and so on. It constitutes a work of reference which should be in every manufacturer's hands, as its handiness may just save two days' delivery on a job, a trunk call or an expensive telegram. Thus we advocate our readers should procure a copy for themselves.

Lubricating Oil Tests and their Significance, by J. E. Southcombe, M.Sc. Published by Henry Wells Oil Company, Limited, 739, Salisbury House, London, E.C.2. Price 2s. 6d.

In this book a new type of test—that of the measuring of oiliness is disclosed. Being always a controversial subject, the founder will welcome this authoritative statement. He will not appreciate, however, the indifferent editing nor the absence of either contents page or index.

Macrome Process.—The Macrome process, a British development designed to prolong the life of steel, has been engaging the attention of the British Admiralty, and, we are informed, that that Department is contemplating a long-period test on cutting tools. Several private firms are now using cutting tools treated by this process, with a consequent reduction in costs of about 50 per cent.

Modern Methods of Enamelling Cast Iron.*

By J. H. D. Bradshaw.

The enamelling process, or more strictly speaking, the mixing of the ingredients composing the enamel, has for a very long time been somewhat of a mystery to the layman principally because he has been unable to see how the particles of an enamel form. In the past, old-time enamellers have taken advantage of this fact, and instances are known where they have claimed to possess special formulæ handed down on the deathbed from father to son. They claim, for example, that the new methods of grinding (*e.g.*, pebble or ball mills) do not give the same size and shape of particle as their own crude traditional processes of size reduction. Even the late Dr. Grunwald in his book "The Enamelling of Iron and Steel" states that white enamels ground in the modern type of mill do not give such fine particles neither do the enamels so produced possess such a high degree of opacity as those ground in the older type of stone mills. As a matter of fact, however, it may be stated that experience has definitely proved the method to be immaterial so long as uniformity of particle size is secured in order to give strength to the mass.

Modern methods of enamelling cast iron may be divided into two main groups known respectively as (*a*) the wet and (*b*) the dry process. These processes will be considered in the light of present practice. For the benefit of the uninitiated, however, a very brief outline of the procedure involved in an enamelling plant will be given before passing on to more detailed consideration. This is best accomplished by a reference to the flow sheet (Fig. 1) showing the

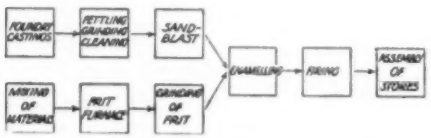


Fig. 1.—Flow Sheet of Enamelling Process Operations.

sequence of operations involved. It will be seen that the castings from the foundry are passed along to the fettling shop for trimming, etc., after which they are sand-blasted and then sent into the enamelling shop. Meanwhile, in another department of the works the enamel is being prepared by mixing together the various materials, after which they are fused, followed by grinding. The ground and prepared enamel is then also sent along to the enamelling shop where it is applied to the castings by one of the methods previously mentioned. After fusing at a temperature of 700 to 900 deg. C., and when cold the enamelled castings are sent forward to the stores for assembling (*e.g.*, stove parts), stocking or despatch to customers.

Preparation of Enamel.

The enamel is prepared by mixing and fusing together such raw materials as ground sand, quartz, felspar, borax, cryolite, fluorspar, sodium and potassium compounds and clay. The required proportions of each for a definite enamel are thoroughly mixed and smelted together The fused enamel is granulated by running into water and ground.

The basis of all enamels is silica (SiO_2) which is obtained from the ground sand, quartz or felspar. Borax or anhydrous boric acid (B_2O_3) is also an essential constituent of nearly all enamels, the possible exception being enamels of the acid-proof type. Enamels entirely free from borax are exceedingly difficult to apply. Cryolite serves the dual purpose of both flux and opacifier. Fluorspar is also another active flux. Barium carbonate is sometimes used in American enamels, and when of a pure grade, is said to produce finished coats of high lustre and density. It produces enamels possessing the easy fusibility of lead, without the poisoning feature attending the use of the latter. Zinc oxide is also a non-poisonous base, and behaves similarly to barium carbonate. Sodium and potassium salts are exceedingly active fluxes. The nitrate of soda (Chili saltpetre) being the most extensively used, largely on the ground of economy, although the potassium salts produce enamels possessing greater brilliance.

Formerly, the raw materials for making the frit were ground, sieved and mixed by hand. The modern tendency is to purchase the various raw materials in a finely powdered condition, and to conduct the mixing in large revolving drums. This mechanical mixing is far more efficient than the former method, and is of intense value, especially in the production of white enamels where the quality of the product is inversely proportional to the length of time required to obtain a thorough melt. The exceptionally fine grinding and thorough mixing as obtained by the use of modern ball mills ensures a uniform fusion product with the shortest possible time in the frit furnace.

The enamel mixture is melted and fined in a smelting furnace until all volatile matter is evolved, and the limpid mass free from lumps of unfused or undissolved material. The best method of detecting the presence of the latter is still the old-fashioned one of examining a string of glass drawn periodically from the melt. When thoroughly fused, the vitreous mass is splintered by running into water and, when cool, ground into a fine powder by means of a ball mill, the latter having completely replaced the older stone mills in modern enamelling plant. If wet grinding (*i.e.*, for the production of a swill enamel) is desired, a flocculating agent or vehicle is added to increase the viscosity of the enamel. The most popular materials for this purpose are magnesium sulphate, magnesia or borax together with prepared enamelling clay.

The frit furnace is of the reverberatory type, very similar to a puddling furnace, but on a smaller scale, the older ones being fired by coal. Experience has shown this method of heating to be unsatisfactory from several points of view. In the first place, it is not economical, and, secondly, frequently produces badly discoloured enamels, through particles of ash, carbonaceous matter, etc., being carried over the bridge into the bath of enamel. Other disadvantages are the wheeling of coal to the furnace, and the consequent removal of ashes, whereby the dust nuisance—the bugbear of successful enamelling—is considerably increased, whilst the time required to heat to the temperature required and the output must not be overlooked.

A modern furnace that is rapidly gaining in popularity for the production of enamels is Podmore's patent frit furnace. This is oil fired, and is made in several sizes. This furnace is sufficiently hot for smelting purposes in one and a-half hours after lighting, instead of the four or five hours required by the old coal-fired one. Batches of enamel are fused in about one hour, as against the two to three hours required with coal firing, and (of greater importance from the point of view of quality) the dust trouble is avoided. A revolving furnace is in use in several American works for the smelting of enamel, but, so far as the author is aware, such a furnace has not yet been used in this country.

Calculation of Enamels.

Enamelling recipes are usually expressed in the form of batch weights, and have been evolved in the past from practical experiments rather after the manner of cooks instead of chemists. These formulæ have "just occurred" after generations of rule-of-thumb working, which, of course, is no guarantee that they are the best possible mixtures. On the other hand, leading enamelling experts have attacked the problem in a scientific manner, and in the compounding of enamels now employ methods of calculation which might be called enamelling stoichiometry. Empirical formulæ are employed to express the compositions of both materials and mixtures. These formulæ show virtually the actual chemical composition, since they contain the relative molecular proportions of the various oxides. They do not, however, attempt to represent the actual chemical or mineralogical constitution, but are simply another step forward beyond the analysis, in the scientific control of the enamelling industry. Seger was the first to adopt this stoichiometric method of mineralogists to ceramic work, and at the present time ceramic chemists almost without exception use it. It may, therefore, be of interest to outline the method, which may be stated in the following paragraphs.

In the construction of the formula, the oxides of the mono- and bi-valent metals, which form bases and act as such in enamels (silicate fusions), are grouped under a general heading, which is called RO. These include the alkalis, alkaline earths together with most of the colouring oxides, *e.g.*, CuO, CoO, FeO, MnO_2, etc. The oxides of the trivalent metals are generally grouped with the Al_2O_3, which is invariably present. It is well known that alumina may play a dual rôle, depending on circumstances, *i.e.*, it may act either as a base or an acid. The R_2O_3 group is therefore often referred to as the intermediary group. Silica (SiO_2) is the principal constituent of the acid group. It is usually present in large quantity, but may be partly replaced by other oxides.

The formula representing a mineral ingredient, a glass, glaze or enamel may be expressed in the general form: x, RO; y, Al_2O_3; z, SiO_2, where x, y and z are numerical coefficients indicating the number of molecular parts of each group present. In enamels, Al_2O_3 has a wide variation, and is sometimes absent. The RO oxides here play an important part, and the custom has been adopted of making RO equal I and give the Al_2O_3 and SiO_2 suitable coefficients to represent their relative molecular proportions. The general enamel formula therefore becomes RO, y Al_2O_3, z SiO_2. It must be borne in mind that RO represents the sum of the oxides, and their individual molecular proportions are such that the sum equals I.

As previously mentioned, Al_2O_3 may vary very widely, and may, in fact, be absent. On the other hand, the oxides of the mono- and bi-valent metals are always present, but may be varied and substituted. Therefore, for convenience when comparing formulæ, it has become the custom in the case of enamels to use such minor numerical coefficients to express the molecular proportion of the various oxides, so that the sum of the basic or RO members equal unity. The general formula then becomes RO, y Al_2O_3, z SiO_2. As an example, the composition of a first-coat cast-iron enamel may be given, being expressed thus:—

Na_2O	0.540	Al_2O_3	0.316	SiO_2	17.362
K_2O	0.026			B_2O_3	1.645
CaO	0.434			F_2	4.408

similarly a cover enamel:

Na_2O	0.749	Al_2O_3	0.312	B_2O_3	0.905
K_2O	0.187			SiO_2	1.279
CaO	0.032			F_2	0.655
MgO	0.022			SnO_2	0.390

It must be clearly understood that these formulæ must not be confused with the chemical

* A Paper read before the Birmingham Branch of the Institute of British Foundrymen, Mr. F. J. Hemming presiding.

formula of a compound. They merely express in a convenient way the proportions of the various oxides present, although they are not introduced as such, neither do they exist in definitely known compounds in the enamel.

Castings.

The surfaces of castings to be enamelled have undoubtedly in the past been a source of great annoyance to the enameller, and great credit is now due to the majority of foundries for their splendid co-operation with the enamelling shop. To-day, castings are supplied to the enameller with a very much better surface and of greatly improved design than was the case only a few years ago. In spite of this improvement, however, it is inevitable that a great many castings, especially light stove parts, etc., still leave the foundry in what, from an enamelling point of view, may be regarded as unsatisfactory. One of the principal sources of annoyance is undoubtedly sand- and blow-holes, and many efforts have been made to develop some method of saving such defective castings from the scrap-heap. These efforts have borne fruit in the production of special fillers of a refractory character, which, at the present time, may be purchased as a proprietary article or even compounded by the enamellers themselves. The fillers used are in a plastic condition, and in order to be successful with them, it is essential that the material is pressed firmly into the hole in order to avoid the formation of an air pocket. If the hole goes through the casting, it is comparatively easy to fill, because there is then no danger of forming an air pocket in the filler. Ordinary surface holes are readily filled by the use of these fillers, over which the enamel may be applied as usual.

Design of Patterns.

It is with pleasure one notices the modern tendency to eliminate sharp edges on castings for enamelling. Experience having shown that enamel will not adhere to such edges but simply run away from them during firing, leaving unsightly black lines, which considerably detract from the beauty of the finished ware. This difficulty being more pronounced with light-coloured enamels. Sections of castings should be uniform, because on the one hand porous metal may be formed at the heavy portions, and on the other, there is a great liability of the enamel not fusing correctly over heavy sections, thereby causing pinholes. Fortunately, for all interested, both foundry practice and enamelling technique are in complete harmony respecting this feature.

Where castings have to be assembled after enamelling, due allowance must be made for the growth that takes place during the necessary heating. Additional allowance must also be made for the thickness of the enamel coating. The latter is considerably greater in the case of dusting enamels than when wet-process enamels are used.

Sand-Blasting.

Before the enamel can be applied it is essential that the surfaces of castings are thoroughly cleaned. Experience has shown that this cleaning is best obtained by means of a good sand-blast. In addition to removing grease, rust, oxide or other foreign matter from the surface, it produces on the casting a slightly roughened or "etched" surface to which the enamel will adhere most tenaciously.

Enamelling.

At the present time the enamelling of cast iron is conducted by two processes known respectively as (*a*) the dusting and (*b*) the wet-process. The dusting process is the older method, and to-day it is found that, in principle, the actual coating operation is still conducted on the same lines as practised 60 years ago. The articles are heated to redness in the muffle furnace, withdrawn, and the hot casting is dusted with the dry powder enamel. Afterwards the casting is again put into the furnace where it remains until the enamel fuses. It is true the original tulle bag has been replaced by the modern enamelling sieve, also, the old practice of coating the cold casting with a gum solution to which the powdered enamel adhered until vitrification takes place has completely disappeared.

Improvements have, however, been made, mainly in two directions, namely (1) in the quality and composition of the enamels employed, and (2) in the improved type of furnaces now available. Formerly these enamels contained large quantities (up to 60 per cent.) of lead oxide, and were invariably opacified with arsenious acid (As_2O_3). To-day there is a great tendency towards the abolition of lead-containing enamels. Even the low fusing point transparent majolica enamels are now being produced completely free from this objectionable material. For this change great credit must go to the Continental enamellers, who were early in the field in the attempt to produce non-poisonous enamels. For some years non-toxic enamels have been in use on the Continent. English enamellers, on the other hand, have been more reluctant to change, and until quite recently the majority used enamels containing large amounts of both lead oxide and arsenious acid (white arsenic). In between the two extremes we have what may be termed American practice, wherein the enamels employed contain only (approximately) 10 per cent. of lead oxide and are opacified with the harmless tin oxide instead of the poisonous arsenic compounds.

Examples of typical compositions are given in Table I, No. 1 being representative of an English enamel, No. 2 an American, while No. 3 is a Continental enamel.

Table I.—*Typical Compositions of Enamels.*

Compound.	1.	2.	3.
B_2O_3 ..	10.00	7.84	14.66
SiO_2 ..	24.00	35.54	35.00
Na_2O ..	4.00	12.55	14.19
SnO_2 ..	—	27.60	13.35
F_2	—	—	4.86
Al_2O_3 ..	—	1.93	11.35
K_2O	—	1.10	6.35
MgO	—	2.27	0.24
CaO	—	0.02	—
PbO	56.00	11.15	—
As_2O_3 ..	6.00	—	—

Wet Process.

This is a more modern process than the original powder process, and at present one finds, broadly speaking, two modifications in use. For convenience these will be referred to as (*a*) the Continental, and (*b*) the American methods. The Continental method was introduced on the Continent prior to 1860, and briefly consists of first coating the casting with a refractory first coat by means of either spraying or dipping. When this first coat is dry, the casting is placed in the muffle furnace until red. It is then withdrawn and, when cold, the coating is moistened with water and the cover enamel applied—also by either spraying or dipping. When this is dry, the casting is again placed in the furnace, where it remains until the enamel becomes glossy. The first coat will have a dull, porous or biscuit appearance, and should not furnish any particles when scratched with the thumb nail.

The American method is of more recent introduction, and is virtually a modification of the enamelling process as applied to steel. The enamels used are essentially of low fusing point, and therefore of great assistance when enamelling castings wherein warping or distortion must be avoided, or where the castings must fit after the enamelling operation, *e.g.*, stove parts, etc. This process may be used to produce two effects, viz., (1) an even coat of white or colour, or (2) to produce a mottled enamel. To produce an even coating of enamel, the sand-blasted casting is sprayed with the moist enamel of the desired colour, allowed to dry, and then run into the muffle furnace, the temperature of which should be about 750 deg. C. It takes about 12 min. for the enamel to mature, or, to use the shop expression, "run up." The casting is then withdrawn, and allowed to cool, when in most cases it will be a finished article. Should, however, it not be sufficiently dense, or should there be any flaws, it may be resprayed and fired again.

To produce the mottled surface, the sand-blasted cast iron is sprayed with either black or coloured enamel, dried and fired. When cold, the mottling is effected with white enamel, by means of a sponge brush or aerograph and, when dry, refired. A number of works using this method do not make their own enamels, but purchase the granulated frit from firms specialising in its production. The frit is ground by the consumer, who makes the necessary addition of water, clay and colouring oxide in order to produce any desired colour.

Comparison of Processes.

Castings enamelled by the dusting process present a beautiful appearance—similar to porcelain—but the method possesses several disadvantages, among which may be mentioned the following:—(1) The enamels used, especially for cast iron, must be of relatively low fusibility; (2) owing to low output per furnace and the highly-skilled labour required it is expensive; (3) the method is wasteful of enamel; and (4) it is unhealthy for the workmen.

By means of the wet process, hard, high-fusing point, acid-resisting enamels may be used, the application of which would be difficult, if not impossible, to apply by the dusting process. These enamels are far more durable and in addition are highly resistant toward acid attack, this in itself being a decided advantage over the soft-dusting enamels, which are, owing to their composition, very poor acid resisters, and will often disintegrate under the action of moisture alone. In addition, the process has the further advantage of being far more economical in production, because less-skilled labour is required; in fact, girls do quite a lot of the coating. Further, there is a much larger output per furnace, because the articles may be fired in batches instead of singly. On the other hand, the value of having every individual casting handled and coated separately by a skilled workman must not be overlooked.

It is found in practice, that less warping occurs with the wet-process method than with the dusting process—possibly due to the lower working temperature. Warping does, however, sometimes take place, chiefly through faulty design, when it is practically impossible to rectify it. Such rectification may be easily accomplished when each casting is treated individually when using the dusting process. It must be borne in mind that the wet process is essentially a means of mass production, and output may be considerably reduced when a man has to lose time by placing weights upon warped castings.

Castings enamelled by the wet process are capable of having far more work expended on them than was formerly the case with the dusted enamels. For example, castings may have been enamelled which should have had holes drilled in them. If the wet process of enamelling has been employed, drilling may be conducted without fear of splintering. Such work is utterly impossible in the case of dusted enamels. This difference in properties is undoubtedly due to the difference in thickness of the enamel coating, which is at least three times greater in the case of dusting than when applied by the wet process. Due to this thicker coat of enamel, greater strains are developed on cooling, and a coating results that will either craze, crack or splinter at the least provocation. An additional advantage possessed by the wet-process method lies in the fact that enamel need only be applied to

the surfaces to be covered. Should enamel become sprayed on to any undesired part, it can be removed and cleaned off prior to firing. This is quite impossible with the dusting process.

Modern Enamelling Furnaces.

During recent years great advances have been made in the design and construction of enamelling furnaces. The old expensive direct-fired types of muffle furnaces are rapidly being replaced by those of modern design, heated by either solid fuel, oil, gas or electricity. Reference has already been made to an oil-fired furnace suitable for melting the frit. Gas-heated furnaces of various types have been in operation for several years and are giving every satisfaction. Broadly speaking, these furnaces may be divided into two sections. The one type (Davis) is a muffle furnace employing the recuperative principle of Siemens, i.e., the furnace is actually built over recuperative chambers through which the gases pass and thereby become preheated before actual combustion takes place, valves being provided so that the direction of the gases may be reserved at frequent intervals, exactly as in Siemens open-hearth practice.

Another type (Lucas) does not possess a separate muffle. Combustion takes place at the side of the chamber, and the products of combustion, after passing along the interior of the furnace, make their exit through flues near the charging-door and under the bottom of the heated chamber to the chimney. Experience has shown such a furnace to result in considerable saving in fuel cost. It may be of interest to point out that white enamelling has been successfully conducted in this type of furnace when working on works-produced suction-gas.

Electric Furnaces.

Ten years ago, probably the first electric furnace for vitreous enamelling was installed at the Schenectady Works of the (American) General Electric Company. This furnace was divided into two compartments by a door, the front compartment serving as a preheater for the castings, the other being the high-temperature chamber. Castings were held in the preheating chamber heated to 300 deg. C. for six minutes, after which they were moved into the second or baking compartment by raising the door between the two compartments. Here the castings were subjected to a temperature of 900 deg. C. for a further period of six minutes, after which they emerged in a finished condition. The heating units on both chambers were arranged to give a very even heat distribution and an absolutely uniform temperature during the preheating and fusing periods, both operations, i.e., preheating and fusing, being conducted simultaneously on two different batches of work.

This furnace, in addition to saving time and floor space, greatly improved the quality of the finished castings, and also reduced the percentage of defective work from 20 per cent. to less than 1 per cent. Comparisons between the cost of operating this furnace and an oil-fired furnace, which it replaced, yield some interesting results. The oil furnace consumed 6 galls. of oil per hr., costing 12 cents per gallon = 72 cents per hr. The cost for the same period with electricity was 41 cents, or a saving of 31 cents per hr. in favour of electricity, it being also estimated that production also increased by 50 per cent. Within the last few months a vitreous enamelling plant has been put into operation in England in which an electric furnace is used for fusing. The internal dimensions of the furnace are 4 ft. 6 in. wide by 4 ft. high to the spring of the arch by 13 ft. long, the effective or heated portion being 12 ft. long.

The steel shell of the furnace encases a body consisting of an inner refractory lining, backed by an adequate thickness of heat-insulating materials. The furnace is single-ended and operated by a double-charging machine running on rails placed at right angles to the access of the furnace. Maximum output is obtained by utilising the full internal height of the furnace, special supporting mediums having been designed for carrying the charge. The usual working temperatures are approximately 750 deg. C. for cast irons and 920 deg. C. for sheet steel, and the furnace is equipped with a recording controller working on the potentiometric principle, which enables the temperature to be controlled automatically with a great degree of accuracy. The door is electrically operated from a push-button control situated at the operating end of the charging machine. This enables the furnace to be worked with a minimum of labour, and in consequence of quick and convenient operation the heat losses, due to opening and closing the door, are reduced to a minimum. From an enamelling point of view, extremely good results are being obtained, and the equipment is said to be an economical proposition.

Improved Furnace Appliances.

The industry is now on the threshold of an era of improved alloy cast irons. It is therefore to be expected that the introduction of heat-resisting alloy cast irons for supporting articles in the enamelling furnace will eventually prove of great economic value, as shown by the following comparisons. With ordinary cast-iron supports rapid oxidation and scaling occurs, so that the useful life of this material is only of the order of ten days. Supports or "perrits," made of Nimol metal, have already been standardised by several firms for carrying stove parts and baths in the enamelling furnaces. In practice, it is found that Nimol supports last from six to seven months, compared with seven to ten days for ordinary cast iron. It is also found that warping is confined to one plane, with supports made from this metal, instead of two for cast iron. This is, therefore, of great value, because the important "points" are maintained at their original level.

Several modern plants use alloy irons containing nickel (2 to 3 per cent.) and chromium (1 to 2 per cent.) for supports, from which the work is suspended by means of 80/20 nickel-chrome hooks. A typical installation consists of three inverted-T supports carrying the main-support arm. The latter carries a series cross-arms, to which hooks are attached for carrying the enamelled sheets. The complete equipment is carried on a trolley arrangement which forms the hearth of the furnace.

DISCUSSION.

Mr. E. J. Lewis, who proposed the thanks of the meeting to the lecturer, asked how it was that in nearly 50 per cent. of the cases coming under his notice the enamel was imperfect; it chipped off and created a bad impression among customers. It could hardly be due to rough castings, because Mr. Bradshaw had said sand-blasting gave castings the necessary rough appearance, and enamellers themselves, perhaps, performed that operation apart from foundry operations.

In seconding, Mr. Callaghan inquired whether there was any effect on cast iron caused by melting the enamel in the cupola, and would there be any adverse influence on enamelled cast iron if used in connection with the brewing industry. On the latter point, he wondered whether enamelled cast iron could be safely substituted for existing machines in which gun-metal with tin inside linings were used.

Chipping of Enamel.

Mr. Bradshaw, after the vote had been passed, observed that chipping-off was one of the old bugbears of the enamelling trade. It could invariably be traced to two causes: (1) insufficient cleaning of the casting, and (2) when the enamel coating was applied too thickly. In the first instance he included the texture of the casting surface, which must not be smooth, but must be slightly etched so as to enable the enamel to adhere more strongly or firmly. For this reason bobbing, filing, grinding, or anything of that nature should be avoided as far as possible when castings were to be enamelled. Where such work had to be employed to give the casting a respectable appearance, the smooth surface should be corrected before enamelling by sand-blasting. As to the actual coating, a fine, thin coat adhered far better to a casting than a thick one, and thus chipping set up by cracking was avoided. Answering Mr. Callaghan, Mr. Bradshaw said the melting of enamel on cast iron in the cupola had no effect on the metal, because the enamel was essentially a silicate and would simply pass into the slag. As regards any action on enamel by beer and cider, this depended on the type of enamel employed. It would be necessary to use what was called an acid-resisting enamel; a swill enamel, as distinct from a powder enamel. This swill enamel possessed a high fusing point, contained a large amount of silica, and was valuable for its acid-resisting qualities. Such enamels, however, were somewhat more difficult to apply than the softer lead-containing varieties.

Leadless Majolica.

A Member asked, in reference to majolica, would one expect to obtain the same lustre as from the use of leadless enamel. The Lecturer replied not quite, but added that he had samples of leadless majolica made five years ago which were identical with articles made from lead-containing majolica. It required an expert to differentiate between them, and the resemblance in lustre was sufficiently near for selling purposes. The disadvantage of working leadless majolica was the higher fusing point. As to sand-blasting, referred to by Mr. Lewis, in their lecture on "Sand-Blasting," in December, it was pointed out that with the use of ordinary steel shot there was a tendency to obtain a "peened" surface instead of an etched one, the latter being necessary for successful enamelling. A Visitor inquired would the same drawback apply to cornered—split or angular—shot, instead of round shot. Mr. Bradshaw replied not to the same extent. In fact, they would be able to secure quite satisfactory results if this shot were mixed with sand, but without sand it was not so satisfactory.

A Member raised the point whether any difficulty had been found in enamelling irons of different composition other than those having different coefficients of expansion. Malleable iron, for instance: in which case could the same enamel be used as for the ordinary grey cast iron?

Mr. Bradshaw replied in the affirmative, and said modern enamels could be quite successfully applied to any commercial grey cast iron, or even to malleable. However, he spoke with some reserve in the former case, but his remarks certainly applied to the type of grey iron commonly used in that district: a high-silicon iron with low manganese. If the coefficients of expansion varied greatly, then the coefficient of expansion of the enamel would have to be altered; otherwise grazing would appear, while if the variation was considerable chipping would occur. They might hear a crack when the casting had cooled and find that the enamel had split. However, it was very uncommon to find a cast iron which could not be enamelled with the material available to-day. Enamels were far in advance of those used thirty or forty years back.

Mr. M. Bale inquired whether malleable iron came in the same category as sheet iron. In respect to malleable, he noticed that the lecturer advised the importance of rounding off square corners, but at the same time he would suggest that if lead enamel was applied to sharp corners it would adhere, and it ran very well. On the other hand, leadless enamel did not run so well. For articles associated with the beer industry, however, lead enamel might cause trouble.

Mr. Bradshaw remarked that he had in mind leadless enamel when speaking of acid-resisting

(*Concluded on page* 165.)

Data Required for Intelligent Estimation of Castings Costs.*

The scope of this report attempts to cover information which a buyer of jobbing castings should furnish with a request for prices. Information was received from over two hundred foundrymen, and the report is, therefore, a composite of their views. In addition, the assistance and co-operation of the Grey Iron Institute, the Malleable Iron Research Institute and the Steel Founders' Society of America has been especially helpful.

The production of American jobbing castings in large measure is a joint undertaking of the buyer and the seller, inasmuch as it is customary for the buyer to furnish the pattern equipment and, in cases, flasks, core driers, shell carriers, straightening dies, gauges, etc. For this reason, the foundryman, before he can intelligently quote a price on jobbing work, must have a knowledge of the pattern and other equipment which the buyer has or is to furnish, as his costs of production are largely dependent on the character and extent of the equipment with which he will be supplied.

If the requirements of the buyer, for example, are sufficiently large as to make machine production the most economical method of moulding, and if a price quotation is made on that basis and the buyer furnishes loose or hand-moulding patterns, the foundryman would be unable to get the contemplated production, with the result that his costs would be increased very considerably over his estimate. Conversely, if the buyer's pattern equipment is such as to permit of economical production and he fails to indicate that fact, he is not likely to receive as favourable a quotation as he would be able to obtain had he given complete pattern description.

Information on numerous other factors of production in addition to pattern equipment—such as specifications, dimension, tolerances, surfaces to be machined, grinding and finishing requirements, etc., of which only the buyer has a knowledge—must be given the seller before he can prepare a dependable estimate, fair to both buyer and seller, of the cost of producing the buyer's requirements.

The dependency of the foundryman on the buyer for full facts and detailed information covering his requirements is, therefore, apparent, and the closest and fullest co-operation between the two is always in the interest of both. Where the foundryman makes a price on incomplete information on pattern equipment and without knowing the full requirements of the buyer, there is a temptation to play for safety and to add a contingency for unknown production factors which the buyer's inquiry fails to state.

An inquiry for jobbing castings, therefore, in the interest of both buyer and producer should be complete in its notations of all essential information. The committee is of the opinion that the failure of an inquiry to give full information covering pattern equipment, particularly where it is reasonably well designed for economical production, is as often to the disadvantage of the buyer as it is to the seller.

Furthermore, incomplete information, apart from its effects on estimated costs and quoted prices, usually results in delays in production, unnecessary correspondence and misunderstandings.

Recommendations for Buyers of Castings.

Inquiries from buyers of castings, the committee believes, should give the following essential information which is common to grey iron, malleable iron, steel and non-ferrous castings:—

(1) Kind of metal.

(2) Sample casting or detailed drawing.

(3) If drawing is furnished, the actual weight of the casting should be given. If actual weight is not known, the estimated weight should be given.

(4) Number of pieces to be ordered of each pattern, with delivery dates and schedules.

(5) Description of available pattern equipment and its condition, indicating:—

(*a*) *Type of Pattern.*—Loose (number of patterns and if suitable for mounting on plate); gated (number on gate); plated (number on plate); and machine, cope and drag (number on equipment).

(*b*) *Material from which Pattern is Constructed.*—Wood; brass; aluminium; or white metal; and

(*c*) *Number of Cores per Casting, with Kind and Type of Core Boxes.*—Number of cores to each box; material from which core-box is made; whether designed for core-blowing machines; and number and kind of core dryers (shell carriers).

(6) If no pattern is available, is foundry to make pattern at customer's expense? If foundry is not to make pattern, will it have the opportunity to suggest how the pattern should be made? If buyer is to furnish flasks the size, type and construction should be given.

(7) Drawings should clearly indicate:—(*a*) Important dimensions, dimension tolerances and machined surfaces with amount of finish to be allowed; (*b*) special requirements, such as finish, testing, gauging, special tolerances, disc or special grinding, etc.; and (*c*) specific locations, if any, for symbol numbers, pattern numbers and trade marks, and whether raised or sunken symbols are preferred.

(8) Description of the service or use of the casting. If the castings are to be subjected to pressure, give test to be made and methods of making.

(9) State whether pound price or piece price is desired, and f.o.b. point.

(10) Indicate any special crating, marking or packing.

In addition to the foregoing information which inquiries for castings should show, and which is considered common to all kinds of castings, the following information has special application to specific kinds of castings.

Grey Iron.—(1) Indicate special treatment, if any, such as sand-blasting, pickling, annealing, heat-treating, normalising, japanning, painting, enamelling, polishing, etc.

Malleable Iron.—(1) Are castings to receive any special finish, such as for galvanising, sherardising, plating, etc.? (2) Are castings to receive special operations, such as straightening, drilling, drifting?

Non-ferrous.—(1) Physical and chemical specifications desired and tolerances permitted; (2) are there any royalties to be paid by foundry? and (3) are castings to be heat-treated, machined or to receive any special treatment such as for plating, etc.?

* Report of American Foundrymen's Association Committee on Inquiries from Consumers of Jobbing Castings.

Modern Methods of Enamelling Cast Iron.

(*Concluded from page* 164.)

mixtures. Lead-containing enamels were easily affected by acids, even by fruit juices, which would disintegrate the enamel. As regards sheet iron and malleable iron, his experience was that malleable iron could be successfully enamelled with the ordinary enamels as applied to grey-iron castings. Incidentally the lecturer explained how to avoid pinholes, and when present how to fill them and obtain a good coating of enamel. He quite agreed that lead enamel adhered to corners, but he had been trying to deal with modern methods which aimed at eliminating lead-containing enamels. Sharp corners were best avoided when leadless enamels were to be applied, and by a little modification of the pattern this could easily be done. Even with lead enamels there was an inclination to run from edges, whilst the corners were prevented from being knocked off by allowing a slight radius as suggested.

Random Shots.

"Marksman" during the week learned of a wonderful and secret process for the production of sound aluminium castings. It consists essentially of an addition to the metal, at a certain temperature, of a compound of powdered rice, opium and rye whisky. Ah, I can imagine aluminium founders asking, at what temperature? And what proportions of powdered rice, opium and rye whisky? That I have vowed not to disclose. You see, the secret was revealed to me by a Hindu fakir whose life I saved by handing over to him the wherewithal for a cup of tea and a bun. It was for this magnificence that he betrayed to a European (*i.e.*, me) what is one of the most closely-guarded secrets under the Southern Cross.

* * *

Since "Marksman" cannot break his vow (having no wish to be implicated in one of those unpleasant riddles of the sands), he is doing the next best thing. If, in the near future, a flux comes on to the market under the trade name of "Rysopwi," buy it; it will be splendid stuff. (A Hindu fakir told me so.)

* * *

Miscellany.

This Year's Conference Hint.—Brush up your Newcastle.

A pessimist is a man who invents a combined automatic lighter and match-case.

Q.—What did Lady Godiva say as she was finishing her historic ride? *A.*—"Thank goodness I am nearing the close."

* * *

You probably remember the poem—one of Thomas Hood's, I fancy—about the marvellous one-horse shay; it was made equally in every part, and one day suddenly crumbled to dust. Very fortunately we cannot construct on "one-horse shay" lines, although "Marksman," travelling in certain taxi-cabs and tramcars at times, has meditated upon the possibility. It would be very disconcerting, at the least, to be crossing a bridge and have it dissolve beneath one's feet into nothing more supporting than dust. And merely to think of clothes. . . . Let us be thankful for such small mercies as cracks and threadbare cuffs!

* * *

What a surprisingly large amount of yellow metal the Gold Rush has brought to light. Chimney-sweepers ought to be handsomely busy, because chimneys that grandfathers have not allowed to be cleaned for years can now be swept and garnished. And how much digging has been done around the roots of the old apple-tree? Anyhow, quite a lot of embrocation can be bought for seven-and-sixpence, so that "Marksman" isn't at all concerned about the stiffness of *his* back.

Marksman.

A New Use for Cast Iron.

Whilst at the British Industries Fair we took the opportunity of inspecting a roadway which utilised cast-iron plates as a foundation upon which to superimpose a tarred-slag surface. The plates were 12 in. by $\frac{5}{8}$ in. thick, reinforced by diagonal ribbing and lightened by four circular holes. When laid, the plates interlock and distribute the traffic load over a wide area. We are not sure as to the extent to which concrete is reduced by this method, but, obviously, the major quantity will be eliminated. It is clear that from their use waviness and pot holing will be eliminated. They are being manufactured by the Shotts Iron Company, Limited, 1, Castle Street, Edinburgh. As a serious novel outlet for cast iron, we wish the new development every success.

This Week's News in Brief.

Trade Talk.

Messrs. Joseph Sankey & Sons, Limited, have opened a showroom at 111, New Street, Birmingham.

Messrs. Broom & Wade, Limited, of High Wycombe, have taken over the well-known Browett, Lindley air compressors.

The address of Messrs. Dunlop & Ranken, Limited, engineers and iron and steel stockholders, is now 147, The Headrow, Leeds.

Members of the staff of Messrs. Smith & Wellstood, Limited, Bonnybridge, held their annual whist drive and dance on Friday last.

The Droylsden Foundry, Limited, is being wound up voluntarily. Mr. Arthur Cleminson, 77, Manchester Road, Fairfield, is the liquidator.

Messrs. E. Foster & Son, Limited, brassfounders, etc., of Woolshops, Halifax, have opened a new and additional showroom for baths and bathroom equipment in Halifax.

Workmen employed at the ironstone quarries at Colsterworth, near Grantham, have exposed a small box-like structure which has proved to be a Roman blast furnace for smelting ironstone.

Messrs. Edward G. Herbert, Limited, Atlas Works, Levenshulme, Manchester, have appointed Mr. Bernard D. Eagin, Hillary Chambers, Hillary Place, Leeds, to be their representative in Yorkshire.

Mining & Industrial Equipment, Limited, 11, Southampton Row, London, W.C.1, report having received orders for six Hum-mer screens, three Raymond pulverisers, a Lopulco mill, an Andrews deslimer, and a Clyde dydrator.

Messrs. Ferguson Bros., Port Glasgow, have launched the bucket dredger "Tilbury II," built to the order of the Port of London Authority for service on the Thames. The whole of the machinery has been supplied by the builders.

The coasting steamer "Rowan," built by Scott & Sons, Bowling, to the order of the Frontier Town Steamship Company, Limited, has completed successful trials on the Clyde. Powerful triple-expansion engines with boilers and auxiliaries were fitted by Aitchison, Blair, Limited.

Two Teesside shipyards in addition to the Stockton yard of Messrs. Smiths Dock Company, Limited, are to be sold. They are the Cleveland Yard, Middlesbrough, and Messrs. Craig, Taylor's yard, Thornaby. Commencing on March 15, there will be a four-days' sale by public auction of the three yards.

A merger is announced between two Bury engineering firms, Messrs. Charles Walmsley & Company, Limited, and Messrs. Bentley & Jackson, Limited. Directors of the former join the board of the latter, and Mr. T. D. Nuttall, of Messrs. Bentley & Jackson, joins the board of Messrs. Charles Walmsley & Company.

It is announced that the Soviet Government has decided to make further reductions in the orders placed in the United States, owing to the pressure that the Department of Commerce is exercising on the banks financing Russian business. The bulk of the current orders, especially for excavators, hydraulic plant and Diesel motors, is, therefore, to be placed in Great Britain, Germany and Italy.

A big programme of motor-car manufacture is to be undertaken by the Ford Motor Company during the next twelve months, according to statements in the United States Press. The programme entails the employment of 100,000 men and an expenditure of $52,000,000 (£10,400,000 at par) per month. Sufficient material will be purchased by the company to enable them to produce 1,500,000 cars during 1932.

One of the most important orders for rubber flooring placed in Great Britain has been secured by the Ioco Rubber & Waterproofing Company, Limited, Glasgow, a subsidiary company of Vickers, Limited. Upwards of 4,500 sq. yds. of the firm's well-known rubber flooring are specified in the contract, and will be used to cover the entire floor space of the new electricity showrooms which the Glasgow Corporation are erecting in Waterloo Street, Glasgow.

An extraordinary meeting of Messrs. Kendall & Gent (1920), Limited, machine-tool makers, will be held at Manchester on March 21, at 3 p.m., for the purpose of considering a resolution authorising a reduction of the capital from £150,000 (£130,000 issued) to £63,333 by cancelling 13s. 4d. per share and reducing the nominal amount of each of the shares to 6s. 8d. Certain conditional agreements have been entered into with the loan holders, whereby upon payment of the lesser sum being made the company has the opportunity of reducing loans amounting to £36,366 to £12,122, or a reduction equivalent to the reduction of capital.

Contracts Open.

Crowthorne, April 4.—Pumping plant, comprising 14 electrically-driven pumping sets, for the Rural District Council of Easthampstead. Messrs. H. Humphreys & Sons, 17, Victoria Street, Westminster. (Fee £3 3s., returnable.)

Hull, March 12.—Iron and steel stores, for the Transport Committee. Mr. D. P. Morrison, manager, Transport Office, Albion Street, Hull.

Portland, March 14.—1,330 yds. of 10-in. cast-iron pipes and specials, for the Urban District Council. Mr. W. Shadbolt, manager, Gasworks, Portland.

Wellington, N.Z., June 2.—15-ton electric overhead travelling crane, for the New Zealand Government Railways. The Department of Overseas Trade. (Reference A.X. 11,281.)

Company Reports.

Rivet, Bolt & Nut Company, Limited.—Dividend for the past year of 2½ per cent., less tax.

North British Locomotive Company, Limited.—Final half-year's dividend on the preference shares, making 5 per cent., less tax, for the year, but no payment on the ordinary shares; £45,000 has been transferred from reserve.

Wallsend Slipway & Engineering Company, Limited.—Net profit, £37,334; brought in, £47,618; final dividend of 3½ per cent., tax free, on the ordinary shares, making 6 per cent., tax free, for the year; carried forward, £39,832.

Obituary.

Mr. John James Johnston, marine superintendent of the Tyne-Tees Steam Shipping Company, Limited, Newcastle-upon-Tyne, died at his home in Gosforth on Saturday, February 27, aged 57.

Mr. Gilbert Campbell, who was for many years employed in an official capacity by the Wallsend Slipway & Engineering Company, Limited, has died in a Glasgow nursing home, aged 71. Mr. Campbell retired in 1923 from the post of manager of the fitting-out department.

Mr. Herbert Barker, senior partner in the firm of Knowles & Company, ironfounders, Globe Works, Bradford, died on March 2, at the age of 74. Mr. Barker entered the firm in 1890 on the death of his father-in-law, Mr. John Knowles, who founded the firm in 1862.

The death occurred on March 3 of Mr. Robert Jardine, foreman smelter in Colvilles' Dalzell works. Mr. Jardine had been employed in the works for over 40 years, and took a very active part in the Steel Smelters' Society. He served for a number of years on the executive council, and ultimately became President. He was 62 years of age.

We sincerely regret to announce the death, on March 1, of Mr. James Oswald, a director of Messrs. John Oswald & Sons, Limited, Sleaford Foundry, Sleaford Street, Nine Elms, London. Mr. Oswald was one of the oldest members of the Institute of British Foundrymen, having joined in 1906. He quickly became prominent, and in 1910 was serving on the Council. Together with the late Mr. James Ellis, he founded the London Section, and in 1912 presided over its deliberations with great distinction. Though, in recent years, his business activities precluded his personal participation, his interest never flagged, and his firm was usually represented at important functions.

Patent Specifications Accepted.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

17,397. I. G. Farbenindustrie Akt.-Ges. Aluminium alloys resistant to the action of sea water. 364,507.

122. Christensen, R. H. V., and Dahl, R. S. Process of and apparatus for casting metal under pressure. 364,831.

11,654. Maschinenfabrik Winkler, Fallert, & Company Akt.-Ges. Machines for casting ingots. 364,974.

23,721. Soc. d'Exploitation des Procedes Mahoux. Treatment of steels and other ferrous alloys. 365,034.

31,584. Del Rio, R. G. Manufacture of aluminium. 365,199.

Personal.

Mr. Brooke Reditt has retired after 50 years' service with Messrs. Ruston & Hornsby, Limited, Sheaf Ironworks, Lincoln.

Mr. W. E. Cooper, F.C.S., chief chemist of R. A. Lister & Company, Limited, has been elected a Fellow of Faculty of Sciences.

At a dinner in Coatbridge Town Hall, attended by about 400, Mr. R. B. Tennant, chairman of Messrs. R. B. Tennant, Limited, Whifflet Foundry, and his fiancée, Miss Nan Borland, were presented with a silver salver and silver tea service by the employees of the firm on the occasion of their forthcoming marriage.

For the Attention of the Buyer.

(*Concluded from page 153.*)

special machinery and "gadgets" for convenience in the handling of the job.

Summarised, the buyer is likely to obtain better terms if he gives on his inquiry the following information:—(1) Actual quantity required, (2) annual requirements, (3) frequency of ordering, (4) full details of patterns and corebox equipment available, (5) the period of delivery he can allow, (6) the exact weight of the finished casting, (7) the important points in reference to surface and jigging and (8) difficulties that have previously been encountered.

This may seem rather extravagant demands on the buyer, but by accepting them he will find that herein lies a serious diminution in correspondence, coupled with a likelihood of infinitely better service from the foundry industry.

International Structural Steel Work Congress.—Under the official patronage of the French Government the Association Internationale des Ponts et Charpentes is organising an international Congress, which is to be held in Paris from May 19 to 25.

Future of Pig-Iron and Steel.—In an article in a recent issue of "The Iron Age," Mr. Floyd W. Grady states that, within the next 20 years, one step forward is going to be the discovery of making steel in colours that will eliminate the present slow and expensive methods of painting, etc. Also that the time is not far away when basic pig-iron will no longer be made in the present type of blast furnace. The stand-still period of making basic iron is about over, and during the next five years the scrapping of blast furnaces that cost millions will seem like a terrific waste of money, but the following five years will prove the wisdom of that seeming extravagance. Shorter cuts to the production of basic iron will prove to be an immense saving.

PROVED EFFICIENCY IN SERVICE.

14

ROTARY OR ROCKING MELTING FURNACES

HAVE BEEN EQUIPPED SINCE 1928 WITH

PULVERISED FUEL "REMA" FIRING EQUIPMENT

INVESTIGATE THE ADVANTAGES OF PATENTED

BRITISH REMA

PULVERISERS

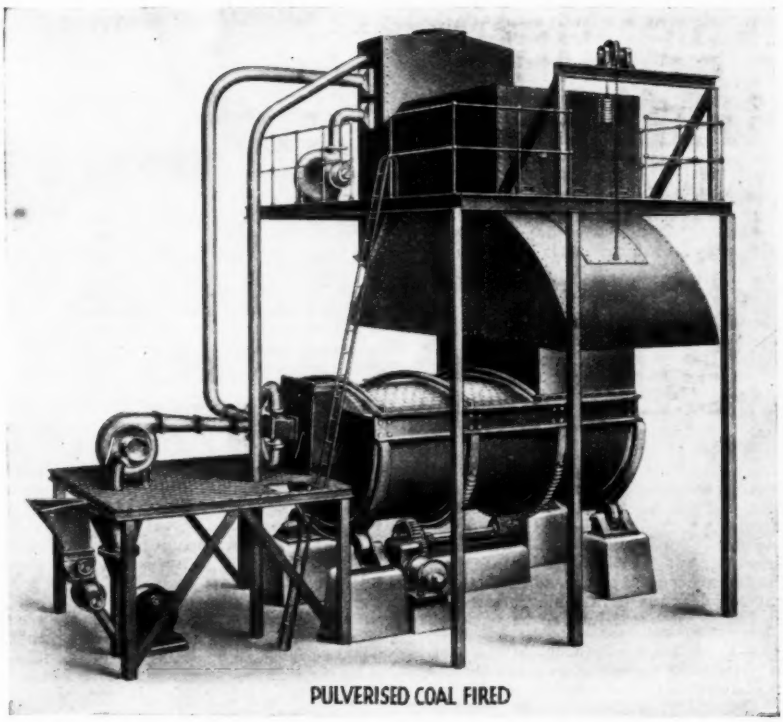
UNIT OR CENTRAL PLANTS TO SUIT REQUIREMENTS.

WE BUILD THREE TYPES OF MACHINE, VIZ.:

RING ROLL MILLS,
BALL MILLS, AND
HIGH SPEED MILLS,

AND CAN OFFER THE MOST SUITABLE PLANT FOR ANY DUTY AND FOR ANY TYPE OF FURNACE.

THE BRITISH REMA SYSTEM OF COMBUSTION CONTROL
(Patent applied for)
IS THE ONLY METHOD OF OBTAINING FULL CONTROL OF MELTING FURNACES FITTED WITH RECUPERATORS OR AIR HEATERS AND USING ANY KIND OF COAL.



PULVERISED COAL FIRED

5-TON SKLENAR FURNACE FIRED BY BRITISH REMA RING ROLL PULVERISING PLANT (UNIT SYSTEM)

(By the courtesy of Messrs. British Reverberatory Furnaces Ltd.)

BRITISH REMA PULVERISED FUEL FIRING EQUIPMENT ALSO EFFECTS SUBSTANTIAL SAVINGS ON
ANNEALING OVENS, CORE DRYING OVENS, MOULD DRIERS, &c.
(OVER **100** PLANTS SUPPLIED FOR FIRING INDUSTRIAL FURNACES ALONE).

THE BRITISH REMA MANUFACTURING CO., LTD.,
HALIFAX, ENGLAND.

Raw Material Markets.

As yet there has been little expansion of actual business in the iron and steel markets, although a far more optimistic tone is prevalent. Recent favourable developments in international finance have ensured more confidence in the general position, but foreign exchange restrictions continue to hamper the export trade. The home demand for pig-iron and semi-finished steel remains quiet, business being mainly for small parcels. The market for finished steel is mainly inactive.

Pig-Iron.

MIDDLESBROUGH.—Only a limited volume of spot business is being transacted in the Cleveland pig-iron market, and consumers are chary of entering into forward contracts; although there is little likelihood of any reduction in prices. There is a decreased volume of deliveries to Scotland, many consumers in that area continuing to use Indian and Midlands iron, the latter being about 2s. per ton cheaper than Cleveland. There are only six furnaces working on Cleveland foundry iron, and their output is being absorbed, mainly by the local works. Prices are unaltered, No. 1 Cleveland foundry iron being at 61s. per ton, No. 3 Cleveland G.M.B. 58s. 6d., No. 4 foundry 57s. 6d. and No. 4 forge 57s. per ton.

New business is scarce in the East Coast hematite market, and keen competition is being experienced. The result has been a severe cutting of prices, the current quotation for mixed numbers being down to 63s. 6d. per ton, and even this figure can be shaded for a large tonnage. Several export orders have been booked for Italy and Scandinavia, but the Continental works continue to force prices down to an unprofitable level.

LANCASHIRE.—Few forward contracts for foundry iron are being placed, users being content to buy iron as the need for it arises. There are still contracts running that were placed last September or October. Deliveries from the furnaces are still on a moderately good scale, but there is a general lack of new orders. Prices have been reaffirmed by the makers. It is generally appreciated that reductions are unlikely, but buyers are not stimulated thereby to engage forward. Derbyshire and Staffordshire No. 3 continues to be offered on the basis of 67s. per ton for delivery to users in the Manchester price zone, with North-East Coast makes also at around 67s., Northants at 65s. 6d., Derbyshire forge iron at 62s., Scottish foundry at about 87s., and West Coast hematite at around 81s. Offers of Indian iron for delivery in the Manchester district at about 77s. per ton continue to be reported.

MIDLANDS.—Very few ironfounders in the Midland area can claim to be operating on a satisfactory scale, and the consumption of pig-iron is limited accordingly. The light-castings trade is now definitely less well engaged, and there is no sign of improving conditions among the general and engineering founders. The demand generally has tapered off. Any buying which is taking place is confined to the satisfying of immediate or early needs, few forward transactions going through. Prices, meanwhile, are unaltered, the furnaces quoting 62s. 6d. per ton for No. 3 Northants and 66s. for Derbyshire, North Staffordshire and Lincolnshire No. 3, delivered Birmingham or Black Country stations or sidings.

SCOTLAND.—No fresh features have developed in the Scottish market, where dullness persists. Scottish pig-iron remains in poor demand. Consumers' requirements are small, and they continue to limit their purchases to supplies to cover current needs. Short-time working at the foundries tends to become the rule, there being few exceptions from this unsatisfactory state of affairs. The light-castings trade remains poorly occupied. Prices of Scottish pig-iron are unaltered at 69s. 6d. per ton f.o.t. furnaces for No. 3 foundry, with a minimum of 2s. 6d. more for No. 1. No. 3 Middlesbrough is obtainable at 58s. 6d. f.o.t. Grangemouth, and other English irons at rather less. Shipments of Continental foundry iron to Scottish ports have practically ceased, and none is now being offered. Scottish hematite is priced at 68s. 6d. and West Coast hematite at 73s., delivered.

Coke.

There is still only a moderate demand for furnace and foundry coke, but the markets are steady and prices are firm. At the same time there is no evidence of anxiety on the part of consumers to purchase other than small lots to supply current needs. Quotations in the Birmingham area remain approximately as follow:—Best Durham foundry coke, 37s. 6d. per ton and upwards; secondary qualities, 35s.; Welsh foundry coke, 30s. to 45s., according to quality.

Steel.

The depression in the finished steel market shows no sign of lifting, and the volume of inquiries remains extremely limited. Little business is being done in heavy material, while there is only a moderate demand for small steel bars and light material generally. The majority of British consumers of Continental semis have heavy stocks on hand, and the market is virtually inactive at the present moment, the very low prices quoted proving no incentive to buy. The home works are receiving a moderate amount of business.

Scrap.

In the Cleveland scrap market heavy steel has weakened considerably, but ordinary cast iron continues at 42s. 6d. per ton and machinery quality at 45s., while the quotation for light castings has fallen to about 30s. per ton. The Midlands market is also experiencing a slack demand, while supplies of cheap textile scrap from the Manchester district are swelling the large quantities of material already on offer. Machinery quality scrap iron is offered at 45s. to 50s. delivered, heavy pipe and plate at 42s. 6d. to 45s., and clean light at 40s. There has been no improvement in the demand in the Welsh and Scottish markets, and prices are weak.

Metals.

Copper.—While the copper market has had to contend with the unfavourable effects of an improvement in sterling, the progress of the negotiations between the producers has led to a more optimistic feeling. At the moment of writing, many conflicting rumours are current as to the proposed curtailment of output, but a further reduction to about 17 per cent. of capacity seems to be indicated. The Customs smelters have withdrawn their c.i.f. quotation of 6¼ cents. per lb., and all c.i.f. sales are now being made at the official level of 6⅜ cents. In London reports have been circulating of good sales being made to the cable makers, and slightly more interest has been shown by consumers in general.

Closing quotations:—

Cash.—Thursday, £34 to £34 2s. 6d.; Friday, £34 7s. 6d. to £34 8s. 9d.; Monday, £34 15s. to £34 17s. 6d.; Tuesday, £33 17s. 6d. to £34; Wednesday, £32 17s. 6d. to £33.

Three Months. — Thursday, £34 10s. to £34 11s. 3d.; Friday, £34 16s. 3d. to £34 17s. 6d.; Monday, £35 2s. 6d. to £35 5s.; Tuesday, £34 7s. 6d. to £34 10s.; Wednesday, £33 5s. to £33 6s. 3d.

Tin.—The price of tin in the London market has remained fairly steady and a fair demand has been experienced. It is difficult to gauge the position in the United States, by which the world tin market is so largely influenced, as reports of business expansion conflict with rumours of curtailment and closing-down. The February statistics afford little enlightenment, there being a drop in deliveries and a decrease in visible supplies; the latter, however, being attributed to the small output at the Straits smelter.

Official closing prices:—

Cash.—Thursday, £139 12s. 6d. to £139 15s.; Friday, £139 15s. to £139 17s. 6d.; Monday, £137 10s. to £137 15s.; Tuesday, £133 to £133 5s.; Wednesday, £129 17s. 6d. to £130 2s. 6d.

Three Months.—Thursday, £141 12s. 6d. to £141 15s.; Friday, £141 12s. 6d. to £141 17s. 6d.; Monday, £139 2s. 6d. to £139 5s.; Tuesday, £134 10s. to £134 15s.; Wednesday, £131 10s. to £131 15s.

Spelter.—Little business has been done with either consumers or dealers, but the market remains steady. Consumers are reported to have stocked large supplies of spelter just before the imposition of the tariff, in which case a quiet market may be predicted for some weeks. Much interest is being taken in the meeting of spelter producers which is to be held on the 17th of this month, in view of the reports that the pool is to be broken up owing to the preference now given in this country to Empire metal.

Daily fluctuations:—

Ordinary.—Thursday, £13 11s. 3d.; Friday, £13 10s.; Monday, £13 5s.; Tuesday, £12 18s. 9d.; Wednesday, £12 15s.

Lead.—A similar position prevails in the lead industry, and the selling pool has had to be dissolved. It is understood, however, that the 20 per cent. cut in output is to be maintained by the producers. There continues to be talk of a "premium" on Empire lead—a development which would be very favourable to British consumers who export their products to the Continent. Some selling has been witnessed of foreign lead bought before March 1, but this has now ceased, and the market shows a steady tone.

The week's prices have been:—

Soft Foreign (Prompt).—Thursday, £12 16s. 3d.; Friday, £13; Monday, £13; Tuesday, £12 17s. 6d.; Wednesday, £12 12s. 6d.

The Institute of Metals.

The Institute of Metals yesterday elected the following officers for 1932-33:—

President: Sir Henry Fowler. *Vice-Presidents*: Mr. W. R. Barclay, Dr. A. G. C. Gwyer, Prof. D. Hanson, Dr. R. S. Hutton, Dr. H. Moore, Vice-Admiral Sir Reginald Skelton. *Honorary Treasurer*: Mr. John Fry. *Council*: Dr. H. W. Brownsdon, Dr. Cecil H. Desch, Mr. M. S. Gibb, Mr. R. Lloyd Gibbins, Mr. H. H. A. Greer, Mr. W. T. Griffiths, Dr. J. L. Haughton, Mr. Wesley Lambert, Mr. H. C. Lancaster, Mr. E. L. Morcom, Mr. A. H. Mundey, Mr. A. J. G. Smout, Mr. J. Steven, Mr. F. Tomlinson, Mr. W. G. Turner, and Mr. H. B. Weeks. *Secretary*: Mr. G. Shaw Scott.

American Iron and Steel Institute: Change of Address.—The American Iron and Steel Institute has leased a large unit of space in the Empire State Building at 350 Fifth Avenue, New York.

Aluminium Industry for Japan.—The Japanese Department of Commerce and Industry is making inquiries into the possibilities of establishing an aluminium industry in Japan by forming a company capable of turning out 12,000 tons of aluminium a year so as to stop entirely the imports of this metal. The material will be got from the South Sea countries, and a Government subsidy will be granted to the company for five years, amounting in total to 5,500,000 yen (say £550,000). The imports of aluminium amounted to 12,000 tons in 1929, to 11,400 tons in 1930, and to 5,000 tons in 1931.

Development of Grid Electricity Scheme.—In a memorandum, the Central Electricity Board point out that since their activities commenced in 1927 they had secured wayleaves for primary and secondary overhead transmission lines, 3,445 miles of the total 3,968 miles provided for in the entire national scheme, with the exception of North Scotland. This leaves only 513 miles to be secured. Almost exactly half of the total was obtained in 1931 alone. Including about 100 miles of cables, required principally for South-East England, the total mileage of all transmission lines was about 4,070 miles. At the end of 1931, 2,310 miles of overhead lines had been erected, an increase of almost 1,500 miles over the 1930 figure and about 94 miles of cables, so that, for Great Britain as a whole, more than 2,400 miles or about 60 per cent. had been built. Lines in actual operation, principally in Central Scotland, South-East England, Mid-East England and Central England, aggregated 910 miles. The progress effected in 1931 was so rapid in practically every area that construction for the country as a whole will probably be completed in 1933.

Pouring light Aluminium Alloy in a modern foundry.

F.T.J. 10.3.32.

"Y" ALLOY

"Y" Alloy attains specially high mechanical properties by virtue of a form of heat treatment. It retains its tensile strength and superior frictional properties at high temperatures. It is largely used for automobile and Diesel engine pistons.

Specified chemical composition, Aluminium 92½%, Copper 4%, Nickel 2%, and Magnesium 1½%.

Approximate melting point ..... 620° C.

Minimum tensile properties:—

Ultimate tensile strength tons/sq. in. 11

Per cent. elongation in 2 in. ..... Nil.

All the British Standard alloys and many other alloys for special purposes are in regular production by the British Aluminium Co. Ltd.; it is usually best to buy metal in this way, already alloyed, from a reliable source.

Our booklet No. 328FJ includes data on alloys of aluminium. It will be sent gratis on request.

ALUMINIUM

THE BRITISH ALUMINIUM Co LTD

ALUMINIUM PRODUCERS, ADELAIDE HOUSE, KING WILLIAM STREET, LONDON, E.C.4.

Telephone:— MANSION HOUSE 5561 & 8074 (5 LINES)

Telegrams:— "CRYOLITE, BILGATE, LONDON."

CAST IRON FLANGED PIPES

2 in.—12 in. & CONNECTIONS. to 24 in. dia.

WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.

JAMES & RONALD RITCHIE, LTD.,

Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."

R. B. TENNENT, LTD.,

COATBRIDGE, N.B.

Telegrams: "Tennent, Founders, Coatbridge." Established 1857. Telephone: No. 425-426, Coatbridge.

IRON & STEEL FOUNDERS

SPECIAL AIR FURNACE IRON. SIEMENS' STEEL ONLY.

HEAVY CASTINGS

OF ALL KINDS FOR IRON AND STEEL WORKS

Iron Castings up to 100 tons each. Steel Castings up to 40 tons each.

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	32 17 6
Three months	33 5 0
Electrolytic	37 0 0
Tough	36 10 0
Best selected	37 0 0
Sheets	66 0 0
India	47 0 0
Wire bars	41 15 0
Do., April	40 17 6
Do., May	40 0 0
Ingot bars	41 15 0
H.C. wire rods	43 0 0
Off. av. cash, Feb.	36 19 8 1/6
Do., 3 mths., Feb.	36 14 2 5/7
Do., Sttlmnt., Feb.	36 19 3 3/4
Do., Electro, Feb.	41 15 11 3/7
Do., B.S., Feb.	40 10 0
Do., wire bars, Feb.	42 4 3 3/4
Solid drawn tubes	10d.
Brazed tubes	10d.
Wire	6¾d.

BRASS.

Solid drawn tubes	9¼d.
Brazed tubes	11¼d.
Rods, drawn	8¼d.
Rods, extd. or rlld.	4¾d.
Sheets to 10 w.g.	7¾d.
Wire	7¾d.
Rolled metal	7¾d.
Yellow metal rods	4¾d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN.

	£ s. d.
Standard cash	129 17 6
Three months	131 10 0
English	131 5 0
Bars	136 10 0
Straits	136 0 0
Australian	134 10 0
Eastern	142 10 0
Banca (nom.)	155 0 0
Off. av. cash, Feb.	139 4 7 3/5
Do., 3 mths., Feb.	141 17 2 3/7
Do., Sttlmt., Feb.	139 4 6 3/7

SPELTER.

	£ s. d.
Ordinary	12 15 0
Remelted	11 5 0
Hard	10 10 0
Electro 99.9	15 10 0
English	13 17 6
India	12 0 0
Zinc dust	23 0 0
Zinc ashes	3 2 6
Off. aver., Feb.	14 1 7 3/5
Aver. spot, Feb.	13 17 5 1/7

LEAD.

	£ s. d.
Soft foreign ppt.	12 12 6
English	14 15 0
Off. average, Feb.	14 11 3 1/2
Average spot, Feb.	14 11 2 3/7

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	24 10 0
Do., V.M. ex-whf.	22 15 0
Rods	29 0 0
Boiler plates	—
Battery plates	—

ANTIMONY.

	£ s. d.
Special brand Eng.	40 0 0
Chinese	29 10 0
Crude	22 0 0

QUICKSILVER.

	£ s. d.
Quicksilver (nom.)	18 7 6

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£7 19 0
45/50%	£12 0 0
75%	£17 10 0
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% c. free, 4/2, plus 55%, per lb. of Mo.	
Ferro-titanium—	
23/25% carbon-free	11¼d. lb.
Ferro-phosphorus, 20/25%	£23 2 6
Ferro-tungsten—	
80/85%	1/8½ lb. plus 20%
Tungsten metal powder—	
98/99%	1/11½ lb. plus 20%
Ferro-chrome—	
2/4% car.	£36 0 0
4/6% car.	£25 2 6
6/8% car.	£24 1 6
8/10% car.	£24 0 0
Ferro-chrome—	
Max. 2% car.	£40 10 0
Max. 1% car.	£49 0 0
Max. 0.70% car.	£56 0 0
70% carbon-free	1/1½ lb.
Nickel—80/99.5%	£235 to £240
Ferro-cobalt	10/9 lb.
Aluminium 98/99%	£95 0 0
Metallic chromium—	
96/98%	3/- lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 0 0
Metallic manganese—	
94/96% carbon-free	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ¼ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	2 5 0	to 2 6 0
Bundled steel and shrngs.	1 17 0	to 1 18 0
Mixed iron and steel	2 0 0	to 2 1 0
Heavy cast iron	2 6 0	to 2 7 0
Good machinery for foundries	2 10 0	
Cleveland—		
Heavy steel	1 15 0	to 2 0 0
Steel turnings	1 12 6	
Cast-iron borings	1 6 0	
Heavy forge	2 15 0	
W.I. piling scrap	2 7 6	
Cast-iron scrap	2 2 6	to 2 5 0
Midlands—		
Light cast-iron scrap	2 0 0	
Heavy wrought iron	2 12 6	
Steel turnings, f.o.r.	1 2 6	
Scotland—		
Heavy steel	2 0 0	
Ordinary cast iron	2 8 6	
Engineers' turnings	1 10 0	
Cast-iron borings	1 11 6	
Wrought-iron piling	2 5 0	
Heavy machinery	2 13 6	

London—Merchants' buying prices delivered yard.

	£ s. d.
Copper (clean)	28 0 0
Brass	21 0 0
Lead (less usual draft)	11 0 0
Tea lead	8 0 0
Zinc	6 10 0
New aluminium cuttings	62 0 0
Braziery copper	24 0 0
Gunmetal	24 0 0
Hollow pewter	90 0 0
Shaped black pewter	70 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	61/-
Foundry No. 3	58/6
Foundry No. 4	57/6
Forge No. 4	57/-
Hematite No. 1	64/-
Hematite M/Nos.	63/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	73/-
„ d/d Birm.	84/6
Malleable iron d/d Birm.	117/6
Midlands—	
Staffs common*	—
„ No. 4 forge*	61/-
„ No. 3 fdry.*	66/-
Shrops basic	—
„ Cold blast, ord.	—
„ „ roll iron	—
Northants forge*	57/6
„ fdry. No. 3*	62/6
„ fdry. No. 1*	65/6
Derbyshire forge*	61/-
„ fdry. No. 3*	66/-
„ fdry. No. 1*	69/-
„ basic*	—

*d/d Black Country dist.

Scotland—	
Foundry No. 1	72/-
„ No. 3	69/6
Hem. M/Nos. d/d	68/6
Sheffield (d/d district)—	
Derby forge	58/6
„ fdry. No. 3	63/6
Lincs forge	—
„ fdry. No. 3	63/6
E.C. hematite	74/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby forge	62/-
„ fdry. No. 3	67/-
Staffs fdry. No. 3	67/-
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	87/-
Clyde, No. 3	87/-
Monkland, No. 3	87/-
Summerlee, No. 3	87/-
Eglinton, No. 3	87/-
Gartsherrie, No. 3	87/-
Shotts, No. 3	87/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£ s. d.	£ s. d.
Iron—		
Bars (cr.)	9 15 0	to 10 0 0
Nut and bolt iron	8 7 6	to 8 10 0
Hoops	10 10 0	to 12 0 0
Marked bars (Staffs) f.o.t.	12 0 0	
Gas strip	10 10 0	to 12 0 0
Bolts and nuts, ¾ in. × 4 in.	12 2 6	
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	8 12 6	to 9 12 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ¼ in. (Untested)	8 15 0	& up.
Flats—8 in. wide and over	8 12 6	
„ under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 0 0	
Hoops (Staffs)	9 10 0	
Black sheets, 24g.	8 0 0	to 8 10 0
Galv. cor. shts.	9 10 0	to 10 5 0
Galv. flat shts.	10 0 0	to 11 5 0
Galv. fencing wire, 8g. plain	12 10 0	
Billets, soft	5 7 6	to 5 12 6
Billets, hard	6 12 6	
Sheet bars	4 15 0	to 5 5 0
Tin bars	4 15 0	

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10¾d.
Sheet to 10 w.g.	11¾d.
Wire	12¾d.
Rods	11¾d.
Tubes	16¼d.
Castings	12¼d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	15.64
No. 2 foundry, Valley	15.00
No. 2 foundry, Birm.	11.00
Basic	16.39
Bessemer	17.39
Malleable	17.39
Grey forge	16.89
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	43.00
Billets	27.00
Sheet bars	26.00
Wire rods	37.00
	Cents.
Iron bars, Phila.	2.11
Steel bars	1.50
Tank plates	1.50
Beams, etc.	1.50
Skelp, grooved steel	1.50
Skelp, sheared steel	1.50
Steel hoops	1.65
Sheets, black, No. 24	2.15
Sheets, galv., No. 24	2.75
Wire nails	1.95
Plain wire	2.20
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	22/6 to 27/6
„ furnace	17/- to 18/-
Durham and Northumberland—	
„ foundry	14/6 to 15/-
„ furnace	14/- to 14/6
Midlands, foundry	—
„ furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	16/-
„ 28×20 „	32/-
„ 20×10 „	23/6
„ 18¾×14 „	16/7½
C.W. 20×14 „	14/-
„ 28×20 „	30/-
„ 20×10 „	20/- to 20/6
„ 18¾×14 „	14/6

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 0 0
Bars, hammered, basis	£16 10 0 to £17 0 0
Bars and nail-rods, rolled, basis	£15 17 6 to £16 5 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

TUBES AND FITTINGS.

Current Discounts.

	Tubes.	*Fittings.*
Gas	65%	57½%
Water ..	61¼%	52½%
Steam ..	57½%	47½%

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Mar.	3 ..	34	0	0	inc.	17/6
,,	4 ..	34	7	6	,,	7/6
,,	7 ..	34	15	0	,,	7/6
,,	8 ..	33	17	6	dec.	17/6
,,	9 ..	32	17	6	,,	20/–

Electrolytic Copper.

		£	s.	d.		
Mar.	3 ..	38	0	0	inc.	15/–
,,	4 ..	39	0	0	,,	20/–
,,	7 ..	40	0	0	,,	20/–
,,	8 ..	39	0	0	dec.	20/–
,,	9 ..	37	0	0	,,	40/–

Standard Tin (cash).

		£	s.	d.		
Mar.	3 ..	139	12	6	inc.	17/6
,,	4 ..	139	15	0	,,	2/6
,,	7 ..	137	10	0	dec.	45/–
,,	8 ..	133	0	0	,,	90/–
,,	9 ..	129	17	6	,,	62/6

Tin (English ingots).

		£	s.	d.		
Mar.	3 ..	141	0	0	inc.	20/–
,,	4 ..	141	0	0	No change	
,,	7 ..	139	0	0	dec.	40/–
,,	8 ..	134	10	0	,,	90/–
,,	9 ..	131	5	0	,,	65/–

Zinc Sheets (English).

		£	s.	d.		
Mar.	3 ..	24	10	0	No change	
,,	4 ..	24	10	0	,,	,,
,,	7 ..	24	10	0	,,	,,
,,	8 ..	24	10	0	,,	,,
,,	9 ..	24	10	0	,,	,,

Spelter (ordinary).

		£	s.	d.		
Mar.	3 ..	13	11	3	inc.	3/9
,,	4 ..	13	10	0	dec.	1/3
,,	7 ..	13	5	0	,,	5/–
,,	8 ..	12	18	9	,,	6/3
,,	9 ..	12	15	0	,,	3/9

Lead (English).

		£	s.	d.		
Mar.	3 ..	14	15	0	No change	
,,	4 ..	15	0	0	inc.	5/–
,,	7 ..	15	0	0	No change	
,,	8 ..	15	0	0	,,	,,
,,	9 ..	14	15	0	dec.	5/–

AVERAGE MONTHLY PRICES OF DERBYSHIRE NO. 3 FOUNDRY AT MANCHESTER.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	2 5 6	2 6 0	2 6 0	2 6 0	2 6 0	2 5 6	2 5 0	2 5 0	2 5 0	2 6 0	2 7 0	2 8 6	2 5 11¼
1897	2 10 0	2 11 0	2 9 0	2 8 6	2 8 0	2 7 0	2 7 0	2 7 0	2 6 0	2 6 6	2 6 6	2 7 6	2 7 9½
1898	2 7 6	2 8 0	2 8 0	2 8 0	2 8 6	2 10 0	2 10 0	2 10 0	2 10 0	2 11 0	2 14 0	2 14 0	2 9 11
1899	2 13 0	2 14 0	2 14 0	2 14 0	3 0 0	3 2 0	3 13 0	3 16 6	3 15 0	3 16 6	3 16 6	4 0 0	3 6 2½
1900	4 0 0	4 0 0	4 0 0	4 1 6	4 1 0	3 18 0	3 13 6	3 12 6	3 11 0	3 11 0	3 9 6	3 8 0	3 15 5
1901	2 13 6	2 17 0	2 15 0	2 15 0	2 14 0	2 13 9	2 13 6	2 13 6	2 14 6	2 13 0	2 12 6	2 16 6	2 14 3½
1902	2 17 6	2 17 6	2 15 6	2 16 9	2 16 6	2 16 6	2 16 6	2 17 0	2 18 6	2 18 6	2 17 6	2 17 6	2 17 1½
1903	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1904	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
1905	2 13 0	2 13 0	2 11 6	2 12 6	2 12 0	2 12 0	2 12 3	2 12 3	2 14 0	2 16 6	3 0 0	3 0 6	2 14 1
1906	3 2 0	3 5 0	3 3 0	3 0 6	2 17 0	2 18 6	2 18 0	2 16 6	2 19 0	3 0 6	3 1 6	3 7 0	3 0 8½
1907	3 7 0	3 7 0	3 5 0	3 2 0	3 4 0	3 8 0	3 6 0	3 5 0	3 4 0	3 2 6	3 1 0	2 18 6	3 4 2
1908	2 15 0	2 14 6	2 14 6	2 15 6	2 14 0	2 13 0	2 13 0	2 11 6	2 12 6	2 13 0	2 12	2 12 6	2 13 5½
1909	2 13 0	2 12 6	2 11 6	2 12 0	2 12 6	2 12 6	2 12 0	2 12 6	2 14 6	2 15 0	2 14 6	2 14 0	2 13 0½
1910	2 13 9	2 14 0	2 14 0	2 14 4	2 15 0	2 15 0	2 14 9	2 15 0	2 15 0	2 15 0	2 15 0	2 15 0	2 14 7½
1911	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 16 0	2 14 6	2 15 0	2 15 0	2 15 8½
1912	2 17 4½	2 17 6	2 17 6	3 1 1½	3 2 6	3 3 9	3 6 3	3 7 6	3 10 10½	3 12 6	3 13 3½	3 14 6	3 5 4
1913	3 15 7	3 15 0	3 11 10½	3 11 4½	3 10 2½	3 6 10½	3 4 2½	3 2 9	3 1 9	3 1 0	2 19 3	2 17 2½	3 6 5
1914	2 17 2½	2 18 0	2 18 0	2 17 0	2 17 0	2 16 7½	2 16 0	3 2 10	3 1 0	2 19 9½	2 16 11½	2 18 1½	2 18 2
1915	3 1 2	3 3 11	3 5 9	3 18 8½	3 13 7	3 14 1	3 15 0	3 13 3	3 12 0½	3 11 1	3 14 0	4 3 3	3 12 2½
1916	4 4 6½	4 11 6	4 11 6½	4 7 6	4 7 6	4 7 6	4 10 0	4 12 10	4 12 6	4 12 6	4 12 6	4 12 6	4 8 6½
1917	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1918	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6	4 12 6
1919	4 12 6	4 12 6	4 12 6	4 12 6	7 2 6	7 5 0	8 8 5	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	7 3 10
1920	9 13 9	10 0 0	10 5 3	10 15 3	11 10 0	12 2 6	12 5 0	13 1 3	14 7 6	14 5 0	14 5 0	14 5 0	12 12 1½
1921	12 11 8	10 8 9	9 2 6	8 2 0	8 0 0	8 0 0	8 0 0	8 1 8	7 4 0	6 7 6	5 7 6	4 16 10	8 0 2
1922	5 5 0	4 17 6	4 15 0	4 15 0	4 12 6	4 12 6	4 12 6	4 12 6	4 11 3	4 10 0	4 10 0	4 10 0	4 13 7½
1923	4 12 8½	5 0 2	6 2 6	6 8 7½	6 2 5	5 11 9	5 9 1½	5 4 0	5 0 0	5 0 9	5 0 7	5 2 9	5 7 11½
1924	5 3 0	5 3 0	5 3 0	5 3 0	5 2 10	5 1 3	4 17 11	4 15 6	4 13 6	4 10 1½	4 10 0	4 10 3	4 17 9½
1925	4 10 0	4 9 0	4 6 9	4 5 2½	4 3 0	4 0 1½	4 17 1½	3 15 7½	3 14 3½	3 13 4½	3 13 4½	3 13 2½	4 1 9
1926	3 14 9	3 15 3	3 15 6	3 15 3½	3 17 6	4 5 9	4 16 9	*	*	*	*	4 12 6	4 0 1½
1927	4 13 9½	4 13 3	4 11 1½	4 9 4½	4 6 1½	3 19 1½	3 16 1½	3 15 6	3 13 4½	3 14 0	3 13 6½	4 1 6½	
1928	3 13 2½	3 12 3½	3 12 3	3 12 3	3 11 6	3 10 0	3 8 3	3 7 8½	3 7 6	3 7 9½	3 8 3	3 7 6	3 9 10½
1929	3 8 3½	3 10 4½	3 10 10½	3 11 0	3 11 2½	3 12 0	3 12 4½	3 14 6	3 15 1½	3 17 0	3 17 0	3 17 0	3 13 1½
1930	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 17 0	3 15 0	3 12 0	3 12 0	3 12 0	3 10 1½	3 9 6	3 14 4½
1931	3 9 6	3 9 6	3 9 6	3 9 6	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 0	3 7 10
1932	3 7 0	3 7 0	—	—	—	—	—	—	—	—	—	—	—

* No prices available during strike period.

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'Phone: 287 SLOUGH

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4-Ton "Evans"	... ...	£28
2-Ton "Evans"	... ...	£19

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PETER—WITH ONE EXCEPTION

With one exception Peter is an ordinary little fellow. Chubby, likeable, just five-and-a-half, full of life and fun, and on occasions—be it admitted—of naughtiness. Just now Peter's rather important, for this is his first term at school, and he's grappling with the intricacies of "A B C" and "Twice-Two": difficult subjects to all men of five-and-a-half, but even more difficult in Peter's case because—bad luck—he's totally blind. That's his One Exception. Peter learns reading, writing, and 'rithmetic through the medium of "Braille"—dull stuff compared with the coloured picture books of most five-and-a-halfs. However, he's a stout lad is Peter, and he's making great progress.

Would you like to know more about him? How, in spite of his "One Exception," he is being educated and, when older, technically trained and usefully employed. There is a long waiting list of "Peters" throughout the British Isles, for whom training and accommodation must be provided in the immediate future.

Will you help with a donation or annual subscription? Any sum, large or small, will be gratefully received.

Here's a suggestion. Your eyesight is worth 3d. a year to you. Send Peter and his handicapped pals 3d. for every year you've had it. Now, please, in case it slips your memory. Good idea?

The Chairman,

SCHOOL FOR THE BLIND
(FOUNDED 1838)
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